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OPENING OF THE MANCHESTER SHIP CANAL.

ALTHOUGH traffic through the Manchester ship canal has been going on since January 1, 1894, the official opening of the canal did not take place until the 21st of May last, when the Queen in person visited Manchester and, as we might say, pronounced her blessing upon the work. The London *Graphic* says: By the visit of the Queen to the ship canal on Monday, May 21, Manchester was enabled to set the seal of highest honor on the splendid accomplishment of a splendid enterprise. The city made the most of its opportunity, and the Queen was graciously pleased to submit herself to as arduous and as protracted a ceremonial as falls to the most indefatigable of our royal family.

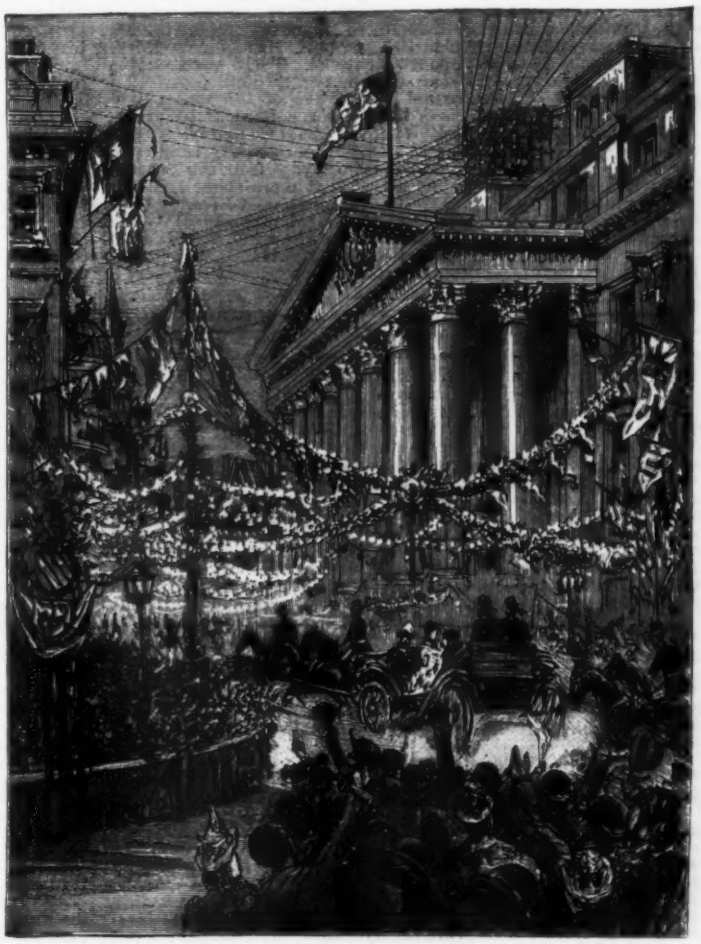
The Queen's interest in the ship canal has always been great—as she said in the admirably chosen words in which she replied to the address presented to her when she embarked upon its waters: "I recognize in this great and important undertaking, and the admirable engineering skill with which it has been constructed, further evidence of the increasing energy and enterprise of my subjects." But even the magnificence of the ship canal might have sunk by comparison with the magnificence of the greeting of the streets. From early morning the excursion trains and the ordinary trains had been pouring into the town the contents of carriages packed, standing, to the windows; and, by the time of the Queen's coming, the principal streets of Manchester and Salford, through which the royal procession was to pass, must have been filled with twice Manchester's population.

When her Majesty emerged from the approach to the London Road Station she looked upon endless lines of upturned faces and upon house fronts where, at every balcony, window and stand, and often upon the housetops, were people waving handkerchiefs in concert with the roar of the crowds below. Flowers stretched across the streets, flowers and pennons ran from mast to mast along the pavement, and scarlet cloth or flaunting flag hung from every window and danced at every corner of masonry. For close upon eight miles and for three hours this was the scene; and these the sounds, varied in degree and detail, but in thoroughness and fine effect constant, which met the Queen's eyes and fell upon her ears.

The journey through the streets and under the triumphal arches of Manchester and Salford, together with the presentation of addresses at various points on the route, may be taken as the first part of the day's ceremonial; the embarkation upon her Majesty's yacht Enchantress at Trafford Wharf, with its attendant presentations, is to be regarded as the second; and the opening of the Mode Wheel Lock as the third, and as symbolically the most important. The addresses which were presented were those of the corporation of Manchester, which was presented at the Town Hall, and which, after referring to the Queen's visit in company with the Prince Consort, neatly introduced the assistance rendered by the municipality to the canal scheme, the welcome of the governing body of Owen's College, which was presented at the Municipal School of Art, the entrance to which had blossomed into roses, lilies and rhododendrons in honor of the occasion; and the address of the borough of Salford, which at the close of its complimentary sentences adroitly observed that the principal locks of this great canal were in the borough.

The Queen's arrival at the gorgeous pavilion which had been erected on Trafford Wharf at the point of embarkation was signaled to the expectant thousands who had been awaiting the Queen's arrival in the mile of scarlet covered stands, and in the gayly dressed steamers along the banks, by running up the royal standard to the button of the flag staff. At the sight the cheers which had run with the Queen's carriage along the lines between which it passed spread far away to distant stands and to distant crowds gathered at convenient points on the sides of the great dock. It should be said, perhaps, for the sake of clearness, that the ships of the canal were mustered at the Salford Docks end; while a long line of pleasure boats successfully hid the inherent griminess of the banks of both sides of the canal, and with their bunting flying from stem to stern gave the correct tone to this novel seaport gala. The gunboats and tenders, whose presence gave color to the observation that Monday was the first appearance of Manchester as a naval port, were moored on the side of the canal opposite to the Enchantress. The Queen only remained for a few moments in the silken pavilion, and then went on board her yacht, where she seated herself on a raised dais in the after-part of the vessel. Accompanying the Queen were Princess Beatrice, Princess Leiningen and Prince Henry of Battenberg. In attendance upon her were Lord Spencer and Lord Carrington. By the Queen's command, the chairman and directors of the company were then presented to her, these gentlemen passing by in review order, and the name of each being announced as he bowed to the Queen. The little ceremony had a distant touch of the drawing room in it.

After the indispensable address, a sentence in the Queen's answer to which we have quoted, had been given and accepted, the lord mayor of Manchester and the mayor of Salford were summoned, bidden to kneel, tapped on the shoulder with the royal sword, and commanded to rise as Sir Anthony Marshall and Sir William Bailey. The public bestowal of this honor had been entirely unexpected, and the crowds in the stands catching sight of the graceful ceremony and suddenly grasping its meaning, began to cheer anew. The Queen was pleased to speak of her gratification at the sight of the great crowds and the abundant decorations, and the newly made knights kissed hands upon retiring.



OPENING OF THE MANCHESTER SHIP CANAL—ARRIVAL OF THE QUEEN AT MANCHESTER

The great event of the day was now approaching nearly. The Enchantress, which had been practicing *her* part in the ceremony for several hours on the previous day, sidled away from the pier, and, with a speeding cheer from the assemblage, steamed slowly upon the waters of the canal toward the Mode Wheel Locks. At the same moment the zealous artillery situated upon the race course at the back of the docks began to fire the royal salute—which, as a matter of fact, had been destined to follow the actual opening of the locks by the Queen. However, the accident did not materially affect the appearance or the prospects of the ceremony, and, in a very few minutes, the Enchantress had reached the locks, had swung round in the most elegant and ladylike way, and was safely moored to the capstans of the piers on either side of the lock gates. A boat put out from one of the piers, took a coil of wire from the Queen's yacht, and sped swiftly back again to the quay. There were a few minutes devoted to rapid adjustment, and then the Queen pressed the ivory button of the mechanical arrangement which stood beside her on the deck. An electric bell trilled somewhere on the quay, there was a movement of suspense while the horrid thought flashed for a moment into the mind that something might have gone wrong after all, and then the huge dock gates opened gently, opened (to quote an eloquent spectator) as softly as a lady's fan. The Queen said "I now declare the canal open." A rocket shot upward as she spoke the words, the band burst jubilantly into the national anthem, and the ship canal was open to the commerce of the world.

THE MANCHESTER SHIP CANAL.

FOR many years Manchester has lain at the feet of Liverpool. This fact has long been recognized, for over fifty years ago we find Liverpool boasting that she paid more window taxes than Manchester; and, as a writer of that day has said, "nothing could better prove the actual state of affairs, for it shows Manchester to be our great workshop, and Liverpool the residence of the non-producers who live upon its industry." Two hundred years ago Liverpool was a fishing village, but with the growth of the cotton industry in South Lancashire came the need of a point of import for raw material and of export for the manufactured goods.

So rapidly, indeed, has Liverpool risen, that whereas in 1801 her year's tonnage was 459,720 and her dues received £28,365, in 1881 they had risen by steady growth to 7,893,950 tons and £966,280 respectively. But these same dues, admittedly overheavy, added to the exorbitant railway rates between port and mill, were a deadly tax on the Lancashire manufacturer, and a time came at last when the keen competition of foreign rivals compelled him to ease himself of the burden.

The ship canal as now constructed is the realization of an idea over one hundred and eighty years old; an idea frequently recurring from time to time and ever growing in importance and ambition.

Passing over many schemes, more or less feasible, for improving the water communication between the estuary and city, we come at last to the year 1877 and the inception of the present scheme. The idea then first discussed was the construction of a tidal channel right up to Manchester, and this scheme, prepared by the late Mr. Hamilton Fulton, C.E., of Westminster, found much favor in many quarters. And there is something peculiarly attractive in the idea of "the briny" actually flowing under the very walls of the cotton mills. However, when, in 1882, the scheme was seriously faced under the leadership of the late Mr. Daniel Adamson, with a view to the immediate construction of the long discussed waterway, two schemes were submitted to the promoters—the one, as we have just said, by Mr. Fulton, for a tidal channel, the other by Mr. E. Leader Williams, C.E., of Manchester, for a channel tidal up to Warrington, and thence rising step by step, by means of locks, up to the old river level at Manchester. It was then realized for the first time that the tidal scheme would involve a cutting over 90 ft. deep at the Manchester end, and that the quays themselves would be over 50 ft. below street level. In addition to this, there were serious doubts as to the satisfactory working of the tidal flow along a confined channel of such great length.

At the preliminary meeting of supporters, held in September, 1882, it was, therefore, decided to adopt Mr. Williams' scheme for a canalized channel. At the same meeting it was also resolved that a fund of £100,000 should be raised to defray the expenses of an application to Parliament for powers to carry out the scheme.

Then followed the most protracted struggle ever known in the history of private bill legislation. Practically it lasted for ten years, the first three years being spent on the passing of the first bill. The most formidable opponents of the bill were the Mersey Docks and Harbor Board, the Mersey and Irwell Navigation Company, Bridgewater Canal Company, city of Liverpool, London and Northwestern Railway Company, and other strong vested interests. It is probable that this persistent opposition has cost the promoters nearly a quarter of a million, but, at the same time, it is quite certain that the scheme just completed is in many ways much more satisfactory than that first laid before Parliament. The bill received royal ascent in August, 1885. The proceedings in all had extended over one hundred and seventy-five days, and over one hundred and seventy-five thousand questions had been asked and answered. After the passing of the bill came the hard struggle to raise the necessary funds for construction. The capital required was about £8,000,000, with an additional £2,000,000 for the compulsory purchase of existing canals and navigation rights. First a London syndicate and afterward the Rothschilds, of London, attempted to float the company, but in vain. But it was not until 1887, on the reconstruction of the board, with Lord Egerton, of Tatton, as chairman, that further powers as to share

capital were obtained, and, through the agency of Messrs. Baring & Co., the capital required by the act of 1885 was subscribed.

No time was now lost before breaking ground. Mr. T. A. Walker, whose name will ever be associated with the successful construction of the Severn tunnel and other heavy engineering works at home and abroad, undertook to construct the entire waterway within four years for the sum of £5,750,000. Lord Egerton, of Tatton, the chairman, cut the first turf at Eastham on November 11, 1887, and work was begun on the various sections before the end of the year. It is difficult to convey to the lay mind the magnitude of the task undertaken, the amount of excavation alone being simply enormous. Imagine a mound of earth 3 ft. broad and 4 ft. high, formed round the globe along the line of the equator, and some slight idea will be gathered of the quantity of rock, sand, clay, and earth which has had to be removed. To accomplish this, an army of men and boys was employed, and, at the busiest time, these amounted to between 15,000 and 16,000. Even such a mighty host would have been of comparatively little avail if steam plant had not also been largely employed. As a matter of fact, the amount of plant employed has never been equaled on any other engineering work. No less than 215 miles of full gauge railway track was laid in the cuttings and along the banks and tips. The rolling stock of this extensive little railway system amounted to 180 locomotives and over 6,000 trucks. The bulk of the digging was accomplished by ninety-seven steam diggers of various makes, aided by a fleet of half a dozen powerful steam dredgers. Heavy as was the work of rough excavation, it was but a portion of the task faced by the contractors. Five main lines of railway had to be diverted, and lofty embankments leading to new high level viaducts had to be formed for them. Roads innumerable were severed, and provision had to be made for the traffic by the construction of seven immense swing bridges and two high level fixed structures. On the estuary portion of the work several miles of embankment had to be formed to separate the canal from the river in order to maintain full depth of water in the canal at low tide.

As the canal has a fall of over 60 ft. between Manchester and the sea, it was necessary to break up the total length into a series of level ponds, divided by locks having a lift varying from 13 ft. to 16 ft. There are in all five sets of these locks, each of massive construction and immense size, situated respectively at Eastham, Latchford, Irlam, Barton, and Mode Wheel. Those at Eastham are three in number, the sizes being 600 ft. by 80 ft., 350 ft. by 50 ft., and 150 ft. by 30 ft., but they only come into use between half tide and low water; the gates standing wide open during the period of high water, so that vessels may pass in or out without any obstruction. The distance between Eastham and the next locks at Latchford is twenty-one miles, and throughout the whole of this length the water in the channel is semi-tidal.

At Latchford and at the other points mentioned there are only two locks, the one 600 ft. long by 65 ft. wide, and the other measuring 350 ft. by 45 ft. In order to minimize the waste of water when in use, each chamber has been provided with a pair of intermediate gates to suit vessels of different lengths.

The valley of the Mersey has always been liable to sudden and serious floods, and provision had to be made by the engineers for the rapid discharge of large volumes of flood water coming down from the uplands. For this purpose large steel sluice gates of improved design have been constructed alongside each of the lock systems. These sluices can be raised bodily from the bridge above, and, by lifting them as occasion requires, the depth of water in the pond above can be regulated to a nicety. The five sluices at Irlam, for instance, are capable of passing over 200,000 gallons per second, a body of water far surpassing any Mersey flood on record.

Between Latchford and Eastham there are two long weirs in the embankments to permit the free flow of the tide into and out of the canal, and there are also three sets of storm water sluices, at Norton and Eastham, with two gates each, and at the mouth of the river Weaver. At the latter point there is a series of ten great sluices, and when these are all lifted to the full height, an opening 300 ft. in length and 13 ft. high is formed in the retaining wall, so that no fear need be entertained of a flood on the lower reaches of the canal or the river Weaver.

In addition to the main locks already mentioned there are six side locks of smaller dimensions, to connect the new waterway with existing systems of navigation. These are the Weston Marsh, Weston Mersey, Bridgewater, and Old Quay locks, all in the neighborhood of Runcorn, and two near Warrington, at Walton and at Stockton Heath respectively. By far the most impressive piece of work on the whole line of canal is the new swing aqueduct at Barton. The Bridgewater Canal crossed the Irwell at this point, and as the line of the new canal here follows the old course of the river, it is obvious that some means had to be devised by which sea-going vessels could pass this point without severing the barge traffic on the older navigation connecting Manchester with the South Lancashire coal fields.

The difficulty has been solved by the bold device of carrying the barge canal across the new waterway in a steel trough, which can be turned on its center just as an ordinary road swing bridge. Before turning, however, stop gates at the two shore ends of the canal cutting and at each end of the trough are closed, so that when the aqueduct is swung there is no waste of water. The total weight of the moving portion, which always remains full of water, is over 1,000 tons, and the sight of the immense structure—with perhaps one or two barges floating in it—gently revolving on its pivot is most impressive.

The greater portion of the docks is situated in the borough of Salford, the remainder being partly in the city of Manchester and partly in the township of Stretford. The total area of the water space in the docks is 105 acres, while the quay space amounts to 152 acres, with a water frontage of over five miles. The upper end of the Manchester Dock is within a mile of the Town Hall. The Manchester and Salford Docks are divided from each other by the Trafford Road Swing Bridge, which connects the city with the borough.

In addition to the docks at the terminus, a side dock of 23 acres is being constructed at Warrington. At Partington, a coaling basin of 5½ acres has been formed, connected by rail with the South Lancashire and Yorkshire collieries. Partington thus becomes by many miles the nearest port to these pits, and the export trade in "black diamonds" promises to be no mean item in the future traffic of the canal.

For two years after the commencement of the work all went well; but the death of the contractor, Mr. T. A. Walker, in November, 1889, involved the company in a series of disputes with his executors, who had endeavored to carry on the work, as provided by the terms of his will. For twelve months the work was continued with considerable friction, and in the autumn of 1890 all existing contracts were canceled, and the work, with all plant on the ground, was taken over by the company, who continued the task for some months as their own contractors.

About the same time a tremendous flood burst over the whole valley, and almost every cutting between Warrington and Manchester was drowned out. The loss to the company caused by delay and expense of pumping out the cuttings, repair of plant, and making good the damage done, was enormous. This and the severe winters of 1890 and 1891 are largely responsible for the great ultimate increase of the cost of the canal over the Parliamentary estimates. Early in 1891 the company found themselves at the end of their resources, and being unable to raise any further capital, they appealed to the Manchester City Council for help. The corporation at once responded by obtaining the sanction of Parliament to their advancing any sum up to £3,000,000 on the security of the city rates. It proved ultimately that even this vast sum was not sufficient to complete the work, and Manchester has raised another £2,000,000 for the same object. The city thus becomes the largest shareholder in the concern, and has a majority of members on the board of directors until the loans shall have been fully repaid or the canal converted into a public trust.

On November 25, 1893, the fourth anniversary of Mr. Walker's death, the canal was at length full of water from end to end, and on December 7 the Liverpool ferry steamer Snowdrop, with the corporation and directors on board, passed along the whole length of the canal from Eastham to Manchester, being the first vessel to arrive in the new port. On January 1, 1894, the canal was opened for traffic. There was no actual ceremony, but a procession of crafts of all descriptions passed up the canal in the wake of the lord mayor, the corporations of Manchester, Salford, and Warrington, and the directors of the Canal Company.

Numerous lines of steamers are already running to and from all parts, and we notice from the Board of Trade returns just issued that more sugar has been landed this year at Manchester than at Liverpool. In itself this seems a trivial matter, but as the proverbial straw shows the direction of the wind, so this small item is but the indication of the vast shipping industry which Manchester most firmly believes will be hers in the near future.

A VOYAGE UP THE CANAL.

For some weeks past the well-known Clyde tourist steamer Ivanhoe has been making daily trips along the canal between Manchester and Liverpool. Seeing that she is "billed" to return shortly to her native waters, and again delight the heart of the canny Scot, we propose in imagination to avail ourselves of the present opportunity, and to steam up the new channel, noting the various works of interest constructed in connection with the canal, and the consequent changes which have been made in the district.

Leaving the Prince's Landing Stage at Liverpool at about high water, we rapidly overhaul the tender Skirmisher, having on board the last of the saloon passengers and the late mails for the Cunarder Campania, outward bound; and in a few minutes we pass that leviathan herself at her moorings in the Sloyne. The Blue Peter flutters from her masthead, and the volumes of smoke and steam pouring from her gigantic smokestacks indicate that steam is already fully up for a record run across the Atlantic. Shortly afterward we are abreast of the old line-of-battle ship Conway, now used as a training ship for cadets; and, passing the floating powder hulks moored off Bromborough, we steer toward the southern bank of the estuary, here almost three miles across, and see before us the entrance locks to the canal at Eastham.

The tide having not yet fallen more than a few feet, the entrance gates are still open, so we steam right through the lock chamber, and are at once in the "Port and Harbor of Manchester." Had we arrived at low water we should still have had ample draught in the approach channel, but should have found the lock gates closed. This would have caused a slight delay, while we were being raised to the canal level; but so perfect are the hydraulic contrivances for closing and opening the gates that less than ten minutes would have been lost in the lock. In passing through the lock we notice on our right the twin sluices for regulating the discharge of storm water from the canal, and on the bank beyond we see a fine engine house and accumulator tower for working the hydraulic machinery and for lighting the locks at night by electricity. These last features we shall find at each of the locks on our voyage up stream, the sluices being always on our right, but in every other case the engine house stands on our left hand. For half a mile we pass through a sandstone cutting, and, emerging from this, cross Pool Hall Bay, the waters of the canal and estuary being separated by a great sandstone and clay embankment about a mile long.

Another deep cutting next leads us to Ellesmere Port Bay, across which the canal is again carried by means of a heavy embankment. Ellesmere Port is the terminus of the Shropshire Union Canal system, which connects the Potteries and the "Black Country" with the Mersey, and which now forms a valuable feeder to the Ship Canal. Extensive new quays have been built here in anticipation of increased traffic; and the Ship Canal Dry Dock and Pontoon Company have selected Ellesmere as the site for one of their huge floating pontoon dry docks.

A long spin between the marshy meadows of the Cheshire shore brings us to the mouth of the river Weaver, the only point of special interest passed on the way being the siphon which carries the river Gowy under the canal in two pipes, each of 12 ft. diameter. This work is, of course, invisible from the deck of our steamer. At the mouth of the Weaver stands Saltport, founded in the summer of 1892 for the salt and timber trade on the canal; the impounded waters of the Weaver forming a large pond for the storage of the timber rafts. From this point the canal is carried round the existing docks and outside the twin ports of Western Point and Runcorn, by means of an immense embankment and concrete wall about four miles long. Opposite the mouth of the Weaver this embankment has been cut down to form a tidal weir, as already explained; and at the same point are the ten great storm water sluices to which reference has been made in our history of construction. The Weston Mersey, the Bridgewater, and the Runcorn Old Quay side locks are all formed in this embankment, to allow vessels to pass direct from the old docks into the estuary, instead of navigating the new waterway.

But before reaching the Old Quay lock, we pass under the first bridge spanning the canal. This is the fine viaduct carrying the London and Liverpool branch of the London and Northwestern Railway across the Mersey at Runcorn gap. It existed long before the canal was commenced, but was sufficiently high above high water mark to clear the masts of vessels. The actual headway varies, of course, with the tide, but it is never less than 75 ft. The three main spans are each 100 yards in the clear; so that the Ship Canal, with its bottom width of 120 ft., occupies only half of the Cheshire or southern span. To the north, across the river, lies Widnes, the center of the alkali industry, overhung by its never-lifting pall of inky smoke and nauseating fumes. A few hundred yards up stream of the viaduct the canal strikes inland, leaving the estuary on the left.

Immediately afterward we find the canal temporarily blocked by the first swing road bridge. A deep hoot from our fog whistle warns the operator of our approach; and the bridge swings silently round on its hydraulic pivot, and as gently returns after we have passed. On our way to Manchester we shall have to pass through six more of these swing bridges, which connect the main roads severed by the canal. They vary considerably in weight; the Trafford Road Bridge, between the Manchester and Salford Docks, being the heaviest in the United Kingdom. The weight on its turntable is 1,800 tons. Yet so truly is each of these immense structures poised on its circle of gun metal rollers that they can each be turned in less than ten seconds. Leaving Runcorn behind, we enter the deepest cutting on the whole line of work, and presently find ourselves passing the Norton sluices, where storm waters are discharged into the river above Widnes.

Moore Lane Swing Bridge next comes into view, with its engine house and accumulator tower, but the former needs no tall chimney, as the fuel consumed at this point is oil, instead of coal. Another half mile brings us to Acton Grange Viaduct, an immense structure carrying four railway tracks—the main line of the London and Northwestern Railway Company and the Warrington and Chester branch of the Northwestern and Great Western joint lines. These railways have been raised by means of inclined approaches of easy gradients, so as to give the same clear headway above water as at Runcorn, which has been taken as the standard of height for all the new fixed bridges spanning the canal. We are now passing Warrington on our left, and as we steam through the Stag Inn Swing Bridge, we notice that the Chester Road, which it carries, also crosses the river a few paces away by means of a new girder bridge of an American type. The entrance to the Warrington dock, which has yet to be made, lies about half way between Stag Inn and Stockton Heath Swing Bridges. The river here has been diverted from its old channel round the Arpley meadows, and it is intended by dredging and widening the old bed to form a dock twenty-three acres in extent. Stockton Heath Church stands on the right, just below the fourth swing bridge, and it is so near to the edge of the water that it is possible to throw a stone from the church step on to the deck of a passing steamer. The swing bridge just mentioned has been constructed at the very point of junction of an old barge navigation with the ship canal, and the connecting lock actually stands under the shorter arm of the bridge when at rest.

Another mile of straight cutting brings us to a high level bridge of an entirely different type from any yet passed. This bridge carries the approach road to the new Latchford Railway station. A hint has been borrowed from the great Forth Bridge, and the cantilever principle, of which so much was heard a few years ago, was adopted. Passing now through the Knutsford Road Swing Bridge, and underneath the great skew bridge carring the Warrington and Stockport branch of the London and Northwestern Railway, similar in design to its sister bridge at Acton Grange, we leave at last the tidal waters of the canal, and enter the lock at Latchford. The 600 ft. lock is occupied by the Merchant Prince, outward bound for the Mediterranean with a full cargo of Manchester goods. So we are raised in the 450 ft. chamber. After a delay of a few minutes, we are again under way, and having just been raised 16 ft. in the lock, obtain a much better view of the surrounding country from the Ivanhoe's promenade deck than was possible on the lower reach. About two miles above Latchford we notice two or three huge dredgers at work in the channel, and shortly afterward meet the Manx Fairy, formerly an Isle of Man boat, but now one of the fleet of pleasure steamers owned by the Ship Canal Passenger Steam Ship Company. Leaving the mouth of the river Bollin on our right, the canal bends sharply to the left, and, spanning the deep sandstone cutting, we see ahead the Warburton High Level Road Bridge, similar in every detail to the one at Latchford. At Partington we find a fine viaduct carrying the Midland line from London to Liverpool across the canal and river, at this point very close together. Just above the bridge the canal is widened out to form the Partington Coaling Basin, with laybys on each side of the channel, and we notice that Messrs. Lamport & Holt's fine steamer Oblers lies under one of the tipping cradles taking in her bunker coal before proceeding to Manchester to load for the Brazils. Nearly a mile further up the canal receives the whole flow of the Mersey water coming down from the Derbyshire hills beyond Stockport. The canal itself from this point up to Manchester follows the valley of the river Irwell, and has practically obliterated that tortuous stream.

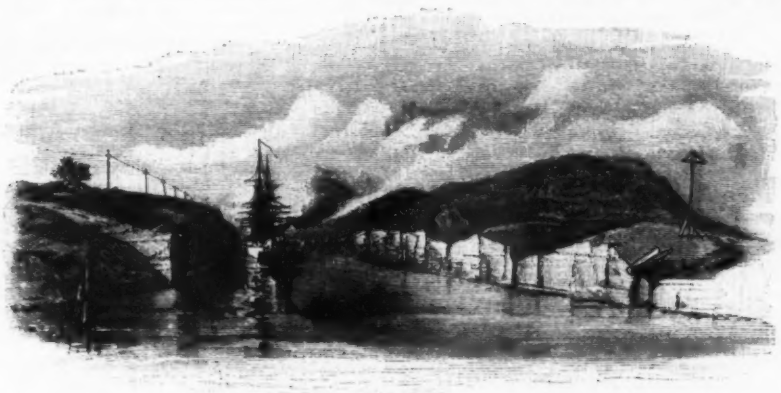
The Cheshire Lines Viaduct at Irlam is the counterpart of the one at Partington, and can carry four trains abreast, though only two lines are at present laid. Immediately above the bridge lie the Irlam Locks. Here we rise another sixteen feet, and after steaming two miles through Lancashire lowland flats, enter the Barton Locks. Here, again, we have another rise in the world, this time one of fifteen feet, in less than as many minutes. All eyes are now strained forward to catch the first glimpse of Mr. Leader Williams' masterpiece—the swing aqueduct at Barton. The concrete island which carries the pivot bears also that of the Barton Road Bridge; and as these two huge structures revolve simultaneously on their axis to give us passage, we hardly refrain from bursting into cheers for the designer of these marvels of engineering skill. From Barton to the docks the canal is cut through the precincts of Trafford Park, the ancestral home of the De Trafford family. Before entering the docks, however, another and final rise of thirteen feet is accomplished in the Mode Wheel Locks. Emerging from these, we find ourselves navigating an immense basin, a mile in length and a quarter of a mile across in the widest part. This is the great Salford Dock, and as we steam gently up to our moorings alongside the Trafford Wharf, we notice that the docks are being fitted up with all the most modern appliances. Electric light has been laid on throughout the whole of their extent; telephone wires run round all the basins, and connect them with the dock offices; hydraulic cranes are being erected as fast as the makers can supply them; while, most important of all, railway lines run along the edge of every quay and jetty, so that goods can be loaded direct to ship, to rail, or *vice versa*, without twice handling, as has to be done at Liverpool.

The Ivanhoe does not pass on to the Manchester Docks, but, like all the other passenger boats on the canal, berths at Trafford Wharf in the Salford Basin. We must therefore leave her here; and take our seats on one of the small steamers plying between the wharf and Albert Bridge in the city. Darting rapidly under Trafford Road Swing Bridge, which we clear without the necessity of its opening, we come to the temporary swing bridge connecting the dock's railways with the Midland and other railway systems. This will shortly be replaced by a permanent structure now in course of erection. The four basins of the Manchester Docks open out on our right. On the opposite bank of the canal, which is here the river Irwell widened and deepened, the construction of the Ordsall Dock is being pushed forward as rapidly as possible. At Woden Street Footbridge we come to the head of the docks, but, continuing our course up the river, we touch at the Regent Road stage, and thence steam to Albert Bridge, within five minutes' walk of the Royal Exchange and the Town Hall.

Having thus covered the whole length of the work, it may be said of us as of a certain queen of old, that "there is no more spirit in us," for truly we have nothing but admiration and praise for the men who have conceived and carried out so vast a work in so short a time; and we can but wish the shareholders and the citizens of Manchester all the success that their boldness and patience merit.

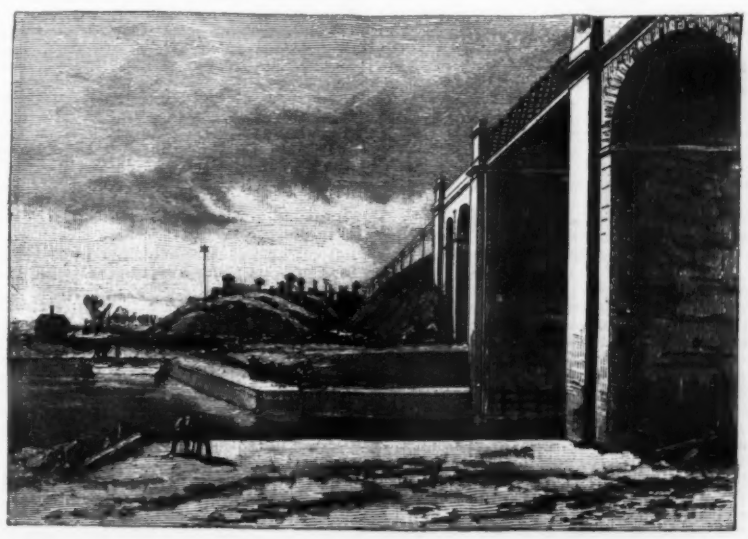
We are indebted to the *Illustrated London News* for our illustrations and the foregoing descriptions of the great work.

Maps and numerous other illustrated details of the canal have been given in previous numbers of our SUPPLEMENT.



THE MANCHESTER SHIP CANAL—ROCK CUTTING, MOUNT MANISTY.

MOUNT MANISTY, FORMED OF THE EARTH THROWN OUT IN MAKING THE MANCHESTER CANAL.



THE VIADUCT OF THE MIDLAND LINE.

A GREAT MINING TUNNEL.

THE ingenuity of Americans has been exercised in the past few years in devising economical ways of operating gold and silver mines. One of the most popular schemes to reduce expenses is a tunnel. Individual mine operators have constructed tunnels of more or less depth, but it has been only in recent years that the transportation tunnel proposition has become popular. During the last days of the silver boom, the number of such enterprises that were suggested or started was legion, but only a few ever became possibilities. Among these is the Revenue tunnel, near Ouray, Col., constructed by the Carolina Company, which owns the Virginius mine on Mont Sneffles.

The mine is one of the highest silver properties in the State. The original workings were 12,500 feet above sea level and over 1,000 feet above timber line. During its best years 350 men were employed in and about the mine, and a post office for their convenience was established in the settlement of the mining cabins perched on the steep mountain side. During the winter season the miners were separated from the world for several months, though occasional trips on snowshoes in favorable weather were made down to the mountain-walled, unique town of Ouray, seven miles below.

When the present owners purchased the Virginius, the privilege of working the mine from the adjoining property was denied them, so that from the outset they had to expend money in developing their property. For thirteen years they prosecuted the work. The Virginius mine has been worked through a crosscut tunnel which burrowed into the mountain a distance of 400 feet. At that point a shaft was sunk upon the vein. The top of the shaft is 300 feet vertically underground, and it is 1,400 feet in depth. In the crosscut, 100 feet in from the entrance, a large room was hewn out of the solid rock to contain the battery of boilers, of which there are three, each of 60 horse power. To get this heavy machinery up from the railroad a wagon road had to be constructed to the entrance. The smoke stack rises through solid rock upward of 300 feet to the surface, where it projects a few feet into space. Electricity has been called into use to facilitate the enterprise. Four and one-half miles away up Canon Creek, Pelton water wheels working under a 525 foot headway operate the dynamos that generate the electricity which is wired down to the mine. The current operates electric pumps with a capacity of 200 gallons of water per minute, besides furnishing light to all portions of the property. The hoists are also worked by means of the electric current.

The mouth of the Revenue tunnel is at an altitude of 10,600 feet, and is three miles by trail below the original entrance to the mine. The first work was done by hand until a distance of 250 feet was reached, when steam drills were put in. When a depth of 600 feet was gained air drills were introduced. The rock proved to be the toughest kind of conglomerate. The drills worked under 120 pounds pressure. So hard was the rock that twenty-four inches of steel was often worn off in twenty-four hours' work with the drills. At a depth of 7,741 feet the tunnel struck the vein at a distance of 2,040 feet vertically below the surface. Where the tunnel intersects the vein an incline has been raised at an angle of 55° for a distance of 840 feet to connect with the upper workings. A double hoist is to be placed in this incline, while a runway for the water and waste and a compartment for ladders and wires are provided. The need of pumping will then be at an end, as the water will pass out by gravity through the tunnel.

Another similar enterprise is the Newhouse tunnel, now being driven into the mountains at Idaho Springs. Three years ago Samuel Newhouse, of Denver, who had been engaged about mining camps for fifteen years, and was the pioneer transportation man in the Leadville rush, conceived the idea of constructing a tunnel to tap at a great depth the veins of gold in Gilpin County. His idea was to construct a subterranean railroad with the gold ores of Gilpin County as the freight to be transported. The tunnel is now a thousand feet long. The great rounded hill known as Seaton Mountain, where Russell Gulch has its source, and where the mining camp of Nevadaville clusters, is the territory to be reached by this underground railway. Within this massive granite mountain there are over 300 known veins of gold-bearing mineral. The cost of operating the mines is considerable, for water has to be overcome by means of expensive pumps, coal must be carted to the mines, shafts sunk, machinery purchased and renewed as greater depth is attained, and the ore transported from the shaft to the mills situated down in the valley. The California mine, now at a depth of nearly 2,200 feet, is operated through a single shaft just large enough to permit a cylindrical bucket to be lowered, and through this small opening the miners must go and the water be taken out before the precious mineral can be brought to the surface.

It is under this territory that the Newhouse tunnel is to be driven with the purpose of crossing these veins. The total length of the tunnel as projected is 20,000 feet, and it will cross the California mine vein at a depth of 2,000 feet from the surface. By this tunnel a complete drainage scheme is assured to all the mines, the cost of transportation of ores will be reduced to a minimum, and, instead of expensive machinery to hoist the waste and the mineral, gravity mining can be carried on. The mouth of the tunnel is at Idaho Springs. The breast of the tunnel is 12×12 feet, rising at a regular grade of 6 inches to 100 feet. Its course is a true tangent. The tunnel will have a double track laid with 30 pound rails, with drainage canals alongside, and the transportation of materials in and of ores out will be done by electricity. The tunnel will be lighted by electricity.

Aspen, a distinctly silver camp, has two big tunnel enterprises, one of which, the Cowenhoven, is now being operated. This tunnel was completed last spring, and is now ready to handle the ores of several mines upon a transportation tariff basis, but no contracts will be made by the proprietors pending the long deferred restoration of the silver market. The other enterprise was stopped in its progress last summer. It was planned to reach the ores of another mountain in the Aspen district.

In Leadville several underground tunnels have been constructed in the past to save expense in operating

some of the deep mines, but no public highway underground was attempted until last spring. Now the Silver Cord tunnel is to be driven under Breece Hill to tap the newly developed gold deposits. Another enterprise, which is still almost visionary, is a gigantic drainage tunnel to be run from the Arkansas River under the hills for several miles to reach the entire Leadville district at a low depth and thoroughly drain the entire territory. The deep mines of Leadville are greatly troubled with water, and the most expensive pumps that can be constructed seem inadequate to protect the lower workings. By the proposed drainage tunnel not only will the expense of fighting water be done away with, but the economical operation of all the mines will be accomplished.

Transportation tunnels in mining districts are proposed upon smaller scales in nearly every camp in the State. As soon as a mine has shown by development that it is a productive property, with a continuous vein of ore of known value, the owners begin to plan a crosscut tunnel in order to reduce operating expenses to a minimum.—*N. Y. Sun.*

THE RELATION OF MATHEMATICS TO ENGINEERING.*

MATHEMATICS has been described in this room as a good servant but a bad master. It will be my duty this evening to prove by suitable illustration the first half of the proposition, and to show the service mathematics has rendered and can render to engineers and engineering.

In our charter the Institution of Civil Engineers is defined as "A society for the general advancement of mechanical science, and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of a civil engineer, being the art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange, and in the construction of ports, harbors, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and adaptation of machinery, and in the drainage of cities and towns." No better definition can, I think, be found for our profession than that it is the art of directing the great sources of power in nature for the use and convenience of man. It covers all that the widest view of our work can include, and it excludes those applied sciences, such as medicine, which deal with organized beings. Mathematics has to deal with all questions into which measurement of relative magnitude enters, with all questions of position in space, and of accurate determination of shape. Engineering is a mathematical science in a peculiar sense. Medicine, the other great profession of applied science, has but little to do with questions of measurement of magnitudes, or of geometry; but the engineer finds them enter into everything with which he has to deal, and enter in the most diverse ways. The thing he has to determine is that the means he employs is enough and not unnecessarily more than enough to attain the end in view. For this he must numerically measure the end and the means and see that they are justly proportioned to each other. It is useless this evening to waste time proving, what all will admit, that no one can be even the humblest engineer without a knowledge of arithmetic and enough of geometry to enable him to read a drawing, that some trigonometry, some rational mechanics and a knowledge of projections, is a very useful part of the mental equipment of a draughtsman. It is hardly necessary to call attention to the great economy in the labor of calculations effected by the use of logarithms, a mathematical instrument for which we are indebted to Napier. We may with more profit examine what use the higher mathematics can be to the practical engineer, and what has been done in the past for engineering by its aid.

Judging from etymology, mathematics must have been begun by engineers; for surely geometry is the work of the earth measurer or land surveyor. But since the prehistoric times when geometry was initiated, engineers have not added much that is new to mathematics. They have rather sought amid the stores of the mathematician and selected the handiest mathematical tool they could find for the particular purpose of the moment, but have done little or nothing in return in the way of improving the tools which they borrow. In this respect the relation of engineering to mathematics differs much from its relation to experimental physics. In electricity, magnetism and heat, engineers have from their practical experience repeatedly corrected the ideas of the theorists, and have started the science on more accurate lines. If our subject to-night had been the use of the practical applied science of engineering in promoting the development of pure mathematics, we should speedily find that there was hardly any material for discussion. The account being all on one side, let us see to what the debt of the engineer to the mathematician amounts.

There is no department of practical engineering in which the application of mathematics is more familiar than in that which relates to the calculation of the strength and rigidity of structures of various kinds. It is impossible to take up any book dealing with the subject without finding that it is crammed either with mathematical formulæ or with geometrical figures. The question is not whether mathematics is necessary to an adequate comprehension of the subject, but whether analytical or purely geometrical methods are more convenient. Of course one might occupy many lectures in discussing the practical application of mathematics to the question of bridge building, roofs, guns, shafting, and the like. Our object must be to illustrate by various examples, rather than to attempt anything like a complete discussion.

Consider the case of a long strut, so long that its transverse dimensions can be regarded as insignificant in comparison with its length. While the strut remains perfectly symmetrical about its middle line, its strength will depend only upon the resistance of the material to crushing. Every one knows that this would be an inadequate conclusion; we have to consider another element, namely, its stability. that is, we must examine what will happen to the strut if from any cause it is displaced somewhat from the direct line between its extremities. A mathematical discussion of the question results in a differential equation of the second order with one independent variable. Upon consideration of this we are enabled to see that if the thrust upon the strut be less than a certain critical value, a slightly bent strut will tend to return to its straight condition; but that if the thrust upon the strut be greater than this critical value, the displacement will tend to increase, and the strut will give way. Further, that the critical value will depend upon whether one or both of the two extremities of the strut are held free, or whether they are rigidly attached by flanges or otherwise, so that the direction of the axis of the strut at this point must remain unaltered. Again, we infer that if the ends are held rigidly fixed, the length of the strut may be twice as great for a given critical value of the thrust as if the two ends are free to turn. We can also infer what the critical value will be for struts of various lengths and of varying cross sections. This critical value depends, not upon the resistance of the material to crushing, but upon its rigidity.

Another example, having a certain degree of similarity with the case of struts, is that of a shaft running at a high number of revolutions per minute, and with a substantial distance between its bearings; for simplicity, we will suppose that there are no additional weights, such as pulleys, upon the shaft. How will the shaft behave itself in regard to centrifugal force as the speed increases? In this case, so long as the shaft remains absolutely straight it will not tend to be in any way affected by the centrifugal force, but suppose the shaft becomes slightly bent, it is obvious to any one that if the speed be enormously high this bending will increase, and go on increasing until the shaft breaks. In this case also we may use mathematical treatment; we find that the condition of the shaft is expressed by a differential equation of the fourth order, and from consideration of the solution of this equation we can say that if the speed of any particular shaft be less than a certain critical speed, the shaft will tend to straighten itself if it be momentarily bent, but that, on the other hand, if the speed exceeds this critical value, the bending will tend to increase with the probable destruction of the shaft. I do not know that either of these two questions can be properly understood without some knowledge of differential equations.

A problem having a certain analogy to those to which I have just referred is that of hollow cylinders under compression from without, such as boiler tubes. Whether the tubes be thick or thin, so long as they are perfect circular cylinders, they should stand until the material was crushed. But if the tubes are thin, what will happen if the tube from any cause deviate ever so little from the cylindrical form? The solution cannot be obtained without a substantial quantity of mathematics.

The next illustration shows how a mathematical conclusion, correct within the limits to which it applies, may mislead if applied beyond those limits, and how a more thorough mathematical discussion will give a correct result. Considering a case of shafting in torsion, it was shown by Coulomb that the stiffness and strength of a shaft having the form of a complete circular cylinder could be readily calculated if the transverse elasticity of the material and its resistance to shearing were known. From the complete symmetry about the axis it is evident that points which lie in a plane perpendicular to the axis before twisting will still be in that plane when the shaft is twisted; it is also clear that the angle through which all points in the same plane move will be the same; hence the problem was as simple as problem could be. But many who had occasion to make use of Coulomb's results gave them an application which was wholly unwarranted. They assumed that they were equally applicable to other cases than complete circular cylinders; they assumed, in fact, that every point of the material which lay in a plane perpendicular to the axis would remain in that plane when the shaft was twisted, whether the shaft was symmetrical about its axis or not, and they consequently arrived at very erroneous results. That the assumption was erroneous is obvious enough from a consideration of an extreme case. In Fig. 1 is shown

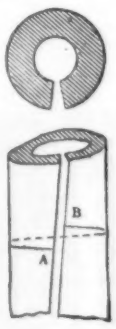


FIG. 1.

in cross section a hollow cylindrical shaft, which is not complete, but divided by a plane passing through its axis. In this case the shaft when twisted will be as illustrated in the side elevation; two points, A and B, were in one plane perpendicular to the axis when the shaft was free from twist; they cease to be in one plane when the shaft is twisted. St. Venant* in 1855 investigated the question of shafts without making incorrect assumptions; he expressed the condition of the material by a partial differential equation of the second order, and gave suitable surface conditions. A general solution of the problem for all forms of shafts has not been obtained, but St. Venant gives a number of solutions for particular forms, and he obtains some general results of interest. In all cases the stiffness of the shaft is less than would be inferred from an erroneous application of Coulomb's theory. Fig. 2 shows diagrammatically the strain in a shaft of triangular section; the full lines indicate that the parts of the shaft which lay in one plane before twisting

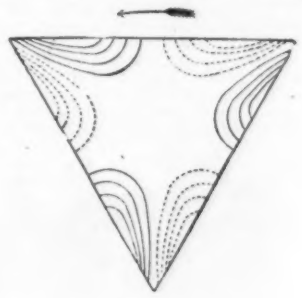


FIG. 2.

when twisted rise above the plane; the dotted lines indicate that they lie behind the plane of the paper. The shearing stress is least at the angles of the triangle, and is greatest at the middles of the sides. At this point then the shaft will begin to break under torsion. The fact is probably well known to men of practical experience, but it is directly contradictory to the conclusion at which one would arrive by a careless use of Coulomb's theory beyond the narrow limits within which it is applicable. The longitudinal ribs which one often sees on old cast iron shafts are useful enough to give stiffness to the shafts against bending, but are good for very little if torsional stiffness or torsional strength is desired.

Another application of mathematical theory which has been carried somewhat further than the premises warrant is found in the case of girders. It is almost invariably customary to treat a girder as though the sections retain when the girder is bent the form and size which they had before bending. Making this assumption, it is very easy to calculate the strength and stiffness of a girder of any section. Unfortunately, the assumption is untrue; but, fortunately, it is approximately true in the case of most girders with which engineers in practice have to deal. That it is untrue can be readily seen from consideration of a girder of exaggerated form, the section of which is shown in Fig. 3.

FIG. 3.

Any practical man would at once see that the outer parts of the flanges would add little to the strength of the girder, but according to the usual mathematical theory the outer parts of this flange should be as useful as the parts which are nearer to the web. This problem St. Venant also deals with in a rigid mathematical manner. Among other things, he showed that a girder of rectangular section, such as shown in Fig. 4, would, when bent, take the form shown by the

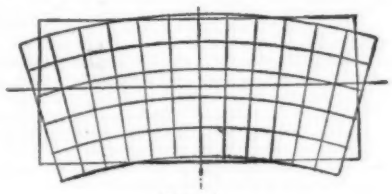


FIG. 4.

curved lines in the same figure. The last two examples show how a little knowledge may be a dangerous thing and how easy it is for any one who attempts to apply mathematics without adequate mathematical knowledge to be misled.

The theory of thick cylinders under bursting stress from within has many important practical applications to hydraulic presses and to guns. It has been discussed more than once in this room. As usual in considering these cases, we are immediately led to differential equations, which here are fortunately solved without serious difficulty, and the solution tells us the whole story. We learn that doubling the thickness by no means doubles the strength of the cylinder. And as a converse, that doubling the strength of the material will permit the thickness to be diminished to much less than one-half. Twenty-five years ago hydraulic presses were mostly made of cast iron. Many people were not a little astonished at the great reduction in thickness and weight which became possible when steel was substituted for the weaker material. In the case of guns it is well known that greater strength can be obtained if the outer hoops are shrunk on to the inner ones.* Mathematical theory tells us what amount of shrinkage should give the best results. It may possibly not be worth while to follow the results of theory precisely, but without the guidance of theory, it would not be unnatural to give so great a shrinkage that the gun would be weaker than if no shrinkage were used.

The rolling of ships in a seaway gives an illustration of a principle which has very varied application in many branches of physics. Suppose a body is capable of oscillating in a certain periodic time, and that it is submitted to a disturbing force of given period, the

* The "James Forrest" lecture, delivered at the Institution of Civil Engineers, by Dr. John Hopkinson, F.R.S., on May 3, 1894.—*Nature.*

* "Memoires des Savants Etrangers," 1855; and Thomson and Tait, "Treatise on Natural Philosophy."

* Lame, "Lecons sur la Theorie Mathematique de l'Elasticite des corps solides." 14th Lecon.

equation of motion easily shows that the resulting disturbance will be great if the two periods are equal or nearly equal. We meet with the principle in acoustics as resonance. If two tuning forks are tuned to the same pitch, and one is sounded in the neighborhood of the other, that other will presently be thrown into vibration by the waves transmitted through the air from the first. You may try a similar experiment at any time on any piano. Strike the higher G in the treble, the sound ceases on raising the finger. Now hold down the middle C, and again strike G; the C string at once takes up the note sounded, and can be heard after the exciting string has been silenced by damping. The same fundamental idea is found in the lunar theory in the term in the equation known as the evection, and again in the theory of Jupiter's satellites. The reason why the metals present in the solar atmosphere give black lines in the spectrum by absorption, corresponding in position with the bright lines in the spectrum which the same metals give when incandescent, is again the same. Gas will absorb or take in from the ether waves of the exact period which it is capable of giving to the ether. The general explanation of all these phenomena is easy. Imagine a pendulum, and suppose it experiences a periodic disturbing force, the first impulse of the disturbing force gives the pendulum a slight swing; the effect of the second impulse depends entirely on when it occurs; it may occur so as to neutralize the effect of the first, or it may occur so as to increase it. If the period of the force is the same as the natural period of the pendulum, the effect of the second, third, and later impulses will be added to the effect of the first and the final disturbance will be great, even though the individual impulses be minute. But the mathematical theory tells us much more than any general explanation can do. It tells us exactly what the character of the effect will be, and its amount, if the periods are nearly but not exactly the same. It tells us, too, exactly how friction affects the results. And the beauty of it is that the mathematical theory is much the same in all cases, so that having learned to deal with one case, we are enlightened as to a host of others. The oscillating body may be an iron-clad, or it may be an atom of hydrogen; the disturbing periodic force may be the waves of the Atlantic or it may be the waves in the ether occurring five hundred millions of millions of times in a second; it is all one to the mathematician; the treatment is substantially the same.

The question of the speed of ships and the power to propel them is probably more effectually treated by experiment on models, as was done by the late Mr. Froude, than by mathematics alone; but in order to learn from the experiments all they are capable of teaching, a mathematical understanding is needed. Given that we know by experiment all about a given model, that we know what force is needed to propel it at every speed, we want to know from these experiments how great a ship, 100 times as big, but similar in form in every respect, will behave; and here mathematics come in to aid us in making the inference.

The construction of ships at once leads us on to the methods of navigating them. In navigation I should find much material for my purpose, but navigation is not usually included in engineering, but many of the implements of navigation undoubtedly are. The mariner's compass has for ages been the mainstay of the navigator, and a simple enough instrument it was till it was disturbed by the iron of which ships came to be built. The disturbance of the compass by the iron of the ship was first seriously attacked by two senior wranglers, Sir G. Airy and Mr. Archibald Smith. The disturbance may be divided into two parts, the first due to the permanent magnetism of the ship, the second to the temporary magnetism induced by the earth's inductive action on the iron of the ship; the first causes the semicircular, the second the quadrantal, error. One has only to open the "Admiralty Manual of Deviations of the Compass" to see how the mathematics of Archibald Smith have accomplished a proper understanding of the subject. The errors of the compass are dealt with in two ways: they are compensated by soft iron correctors and by permanent magnets so placed to have an effect equal and opposite to the effect of the temporary and permanent magnetism of the ship. Or they are dealt with by formulæ of correction which enable the error to be calculated when the course of the ship and the conditions of the earth's magnetism are given, or a combination of the two methods is used. Either method is based on Archibald Smith's theory. It is not possible to leave the subject of the mariner's compass without referring to the great improvements of Lord Kelvin. The improvements relate to every part of the instrument, and I venture to say that none of them could have been made by any one but a mathematician. In order to get his card steady he knew that its period must be different to any possible period of the waves, or he would have the resonance to which I have just referred coming in, so he gave his card a considerable moment of inertia; but this was managed with a light card, so that small needles could be used. If the needles are small, the correction by soft iron masses and by permanent magnets is easier and more accurate. Then the bowl of the compass had to be suitably carried, so that it would not be unduly disturbed by shock, and provision had to be made for damping by fluid friction the oscillations of the bowl if they occurred. Lastly, a most beautiful method of correcting the compass, without taking a sight, was discovered. In every detailed improvement one can detect that the inventing mind was that of a most able and trained mathematician.

An essential of safe navigation is an efficient system of lighthouses. The optical problem of the lighthouse engineer is to construct apparatus which shall usefully direct all the light produced. The present forms of apparatus are in their leading features due to Fresnel, the able mathematician who established on an absolutely firm foundation the undulatory theory of light. To properly design an optical apparatus formulæ must be used, and the advantage is great if the designer can with ease manufacture the formulæ he requires.

(To be continued.)

THE energy exerted by a railroad train traveling 75 miles an hour is nearly twice that of a 2,000 lb. shot fired from a 100 ton Armstrong gun.

THE BROTT ELECTRIC ELEVATED BICYCLE RAILWAY CO.

FROM time to time articles have appeared in the daily and technical papers regarding a projected electric railway between New York and Washington, but until quite recently nothing of a definite character has been given to the public.

On April 2 last, a bill was introduced in the national House of Representatives providing for the incorporation of the "National Rapid Transit Company," which bill was referred to the Committee on the Judiciary. We understand that favorable progress is being made in committee with respect to granting the company the charter it asks for.

The preamble of the bill recites the fact that it is evident that steam locomotion has reached its limit of speed, and that the practice of running passenger and mail trains on the same rails used for the transportation of freight is fraught with danger; that the proposed line will connect Washington with New York, be elevated and operated by electricity, and that a speed of 120 miles an hour or more can be maintained with safety and economy; and, further, that interstate commerce will be facilitated and the general welfare promoted thereby.

Section 6 of the bill provides "That the said road structure and its supports shall be made of iron or steel, of sufficient size and strength to permit the passage of cars on or over the same at a speed of one hundred and twenty miles an hour, and the conduits for the electric current to be so adjusted as to prevent any person from coming in contact with the electric current having sufficient voltage to endanger life, and that said roadway shall be elevated so that the tracks will be two or more feet above the ground, and shall be provided with one or more side rails at such elevation as will reach above the floor and under the sills of the windows of the cars (made to run on said structure) to prevent derailment, and in all other respects to conform to what is known as the Brott system for rapid transit railways; that when the said road passes through the streets of any incorporated city or village or over any public road or highway, it shall be either elevated sufficient for the passage of vehicles under the same or placed below the surface of the ground in such manner as not to impede the traffic of said city or village."

Section 13 provides that the capital stock shall be $15,000,000, which may be increased to $25,000 000 by a vote of stockholders. The shares to be $100 each.

Section 15 relates to the schedule of mail and passenger cars, which shall not be less than 100 miles an hour, and also provides that the charge for the transportation of passengers shall not exceed two cents per mile.

The Brott system, on which it is proposed to operate this line, and which is mentioned by name in the bill above referred to, has some novel features, which will be referred to below.

We are informed that tests have thoroughly demonstrated the feasibility and practicability of the system from a mechanical standpoint.

Water power being obtainable on the Potomac within a few miles of Washington, the company proposes to install a generating plant at a convenient point on the three-phase alternating system, generating current at a comparatively high pressure, and transmitting it either on a substantially built overhead line or in suitable terra cotta or iron ducts insulated in oil, as may hereafter be deemed most advisable, to the Washington terminus of the road. From this point it will form a part of the construction of the rail supports themselves, being carried in a proper manner under the main rails, with suitable distributing and equalizing mains carried under the side rails. A duplicate electrical plant will be installed, in order to insure continuous service all the time. Transformers of the step-down type will be used at frequent intervals, maintaining a positively uniform pressure at all points along the line. The Great Falls plant will supply current to the line from Washington to Philadelphia, another plant being located in the vicinity of Trenton, N. J., to feed the line in both directions to Philadelphia and New York.

Each car will contain four motors of the gearless type directly connected on the axles, two on the front wheel and two on the rear, and while of the multipolar type, will be constructed for high speed.

The motors will make 700 revolutions per minute under full load and will be directly connected to a steel driving wheel, built up in a laminated manner of sheets of steel, in order to get the highest degree of tensile strength, and resist the tendency to burst from centrifugal force. The car being built in the lightest possible manner, comparatively narrow, and pointed at both ends to reduce the air resistance to a minimum (when operated singly, the front and rear cars only being pointed when run in trains), will run at a normal speed of 2½ miles per minute. The weight of the motors will tend to greatly assist in the balancing of the car, aiding materially the traction, and yet permitting the car to rest freely upon suitable springs.

By means of automatic cut-outs, the line wires supplying current directly to the side collecting wheels are cut in sections of 2,000 feet each, every other portion of the line which is exposed being dead except that particular half mile on which the car is situated.

Where cars are run in trains all the motors are controlled by one motorman, in the front car, giving him absolute control of the movement of the train to a much wider extent than can be obtained in heavy and cumbersome steam locomotive and cars. One great advantage in the braking of the train is the fact that the entire current passes through the wheels into the rails, forming a momentary electric welding, which current, when permitted to flow so as to reverse the direction of the motors, enables the operator to bring his train to a standstill in less than one-third the time required by steam or air braking, and thus lessening the danger of accidents. This power of control, combined with the cradle in which the whole train lies, makes an accident of a serious character practically impossible.

The following is a brief statement of the main features of the Brott system:

The structure rests on a single line of iron posts, having a single supporting rail and side rails just below the car windows.

The cross section of this structure is U or trough shape, through which the cars run with great velocity without the possibility of derailment.

A double electric motor is adjusted to each supporting wheel of the cars, making each a traction wheel, and making it possible to ascend a 10 per cent. grade with ease.

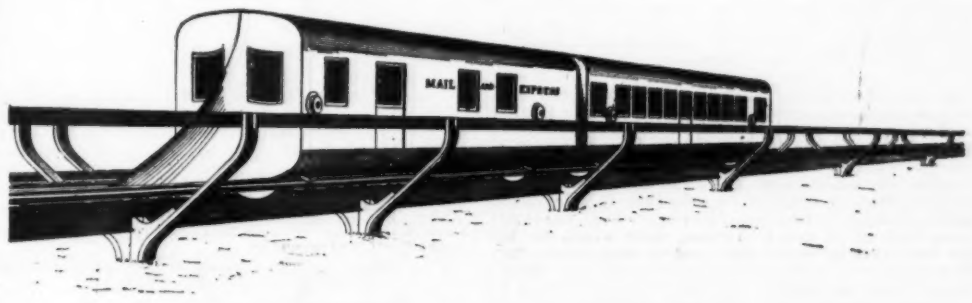
One side rail is charged with electric current, which operates the motors and thence passes through the driving wheel, to the main track, thus completing the circuit.

A train of cars on a steam surface road with a capacity for carrying 150 passengers will weigh over 200 tons, while a train of same capacity on the Brott elevated structure will not exceed 30 tons in weight, making a difference of 170 tons of dead weight which has to be carried whether the number of passengers be few or many.

In the Brott system there is a saving in the cost of operating and in cost of repairs; also time of transit and in land for right of way.

The average track elevation is about four feet, with more at road crossings and in cities, thus avoiding dangerous crossings, and the system is free from danger of washouts, snow blockades, etc.

The structure, which is made of iron or low grade steel, is indestructible, the estimated cost of which is about $20,000 per mile.



THE BROTT ELECTRIC ELEVATED RAILROAD.

When a double track is used the two are connected at the side rails in such manner as to add to the stability of the structure.—*Electrical Age.*

[Continued from SUPPLEMENT, No. 963, page 15382.]

NICKEL—ITS HISTORY, USES, AND DISTRIBUTION.*

By A. G. CHARLETON, A.R.S.M.

THE DISTRIBUTION OF NICKEL.

GEOLOGICALLY, nickel ores are usually divided into three main groups, which broadly correspond with the following classification.

Vogt has employed this subdivision as a foundation for a genetic classification. His groups are:

1. Arsenides, which include sulpho-arsenides and sulpho-antimonides, as well as combinations of the metal with sulphur and bismuth.
2. Sulphides, such as nickeliferous-pyrrhotite and pyrites, millerite, etc.
3. Silicates, garnierite, genthite, etc.

A brief description of a few typical examples of each group is interesting, as throwing light on the general occurrence of the ores of this metal.

The first of these groups is found in veins in Hungary, of the Dobschau type, and in the so-called Kobaltrucken, typified by the Richelsdorf Bieber veins. They occur also (as subordinate minerals) in the silver bismuth cobalt veins of Schneeberg, in the ordinary silver lead veins of Freiberg and in the Gem mine of Fremont County, Colorado.

In addition to nickel cobalt ores of various kinds, Von Groddeck shows that the typical Dobschau veins carry copper, and all these three metals are found in the serpentines and older eruptive lime-olivine rocks, which form "the country" of the veins, and appear to have been produced from the decomposition of the adjacent rock masses, composed of olivine and gabbro. A vein of this class is found at Dillenberg in Nassau, in pickrite, altered to serpentine, and contains millerite, bismuth-glance, pyrite, and other sulphide minerals. This vein was only productive in the serpentine, becoming barren when it passed into the adjoining schaalstein country.

The gabbro in the neighborhood of Dobschau, which has been partly altered, as before mentioned, to serpentine, is fringed by a peculiar green silicious schist, resting on gneiss and granite. The veins occur between the gabbro and the schist, do not possess well defined walls, and often reach a width of 25 feet.

The Schneeberg deposits, which likewise belong to this group, have a special interest for me, as I visited the district in 1880, and had an opportunity of examining its geological features, although my attention was more particularly directed to a study of the methods

* A paper recently read before the Society of Arts.—*From the Journal.*

of dressing these ores, which present particular features of interest in their details.

The veins chiefly occur in mica schist, which passes into clay slate, more rarely entering the deep-seated underlying granite, which, along with basalt, is found in intrusive masses, penetrating the overlying formation in the neighborhood of Schneeberg.

The chief group of nickel cobalt veins lies round Neustadtel, and, in general, strikes from N.W. to S.E., the dip being in some cases N.E., in others S.W., but in all cases highly inclined. The gangue is called, by Von Cotta, hornstone, and they carry, in addition to nickel and cobalt, bismuth, copper pyrites, and silver. He considers them to be veins of infiltration, formed by percolating mineral waters.

Closely connected with this system of veins is an independent group of copper lodes, which strike N.E. and S.W., with an almost vertical dip to the N.W.

These show a great variety of copper and other minerals, among which may be named copper pyrites, bornite, copper-glance, tetrahedrite, cuprite, tenorite, chrysocolla, malachite, azurite, galena, cupreous sulphur of lead, cerusite, pyromorphite, iron and arsenical pyrites, blende, native silver, jasper alophane, dioptase, barytes, and brown spar—a veritable mineralogical museum. The nickel cobalt ores as they are delivered to the dressing works average, I was told, 4 to 6 per cent. of cobalt, 3 per cent. of nickel, and 8 to 10 per cent. of bismuth.

The second or sulphide group of nickel deposits embraces those of Sudbury, Ertali, Piedmont, Varallo, and other places, and possesses very wide distribution and marked geological characteristics. Vogt assumes this class of deposits is usually formed by a process of differentiation, or segregation from a basic eruptive rock-magma, and they are distinguished by the peculiarity that the ore chiefly consists of pyrrhotite, which carries, disseminated through its substance, various nickeliferous sulphide minerals, such as millerite, polydymite, and pentlandite, while chalcopyrite and titaniferous iron usually accompany the iron pyrites, as accessory minerals. The largest and best known deposits of this class are at Sudbury, in Canada, where the ore is found in irregular, lenticular masses in the Huronian rocks, apparently conformable to the planes of bedding, and invariably in proximity to dikes or uptilted sheets of greenstones (diorite) and diabase. From the fact that the greenstones themselves are found at times with ore disseminated through them, Merritt thinks the nickel has been brought to the surface by the agency of these dikes. The region has been much faulted, and in places the pyrrhotite and chalcopyrite form a breccia, in a dark, dioritic matrix. The main range is about 50 miles long and one to four miles wide, running N.E. and S.W. from Lake Wahnapitae to the Spanish River. The nickel deposit outcrops are described as forming hills or ridges.

According to Mr. D. W. Browne, the ore frequently loses the character of a copper ore, which it possesses at surface, becoming more and more nickeliferous and less cupriferous in depth. To illustrate this, he cites (New York *Engineering and Mining Journal*, September 16, 1893) the Copper Cliff Mine, stating that on the 4th and 5th levels the ore carries 4 per cent. of copper and 4·5 per cent. nickel, while on the 7th level many "stopes" show an average of 0·5 per cent. Cu and 8 to 10 per cent. Ni; the evidence, however, so far, would hardly appear to be sufficiently extended to warrant founding any general conclusions of similar enrichment, in other cases, taking place, founded upon what may turn out to be an exceptional occurrence.

As far as the Sudbury deposits have been exploited, down to a depth of 600 ft., there is no sign of falling off in the grade or quality of the ore. It contains in bulk 1 per cent. to about 5 per cent. Ni, and 1 per cent. to 4 per cent. Cu and cobalt; traces of gold and silver, and platinum, in the rare form of sperrylite (arsenite of platinum), is found in it. Ph. Argall, of Denver, in a most interesting paper read before the Colorado Scientific Society, December 4, 1893, gives the following analyses of an average month's output of the Copper Cliff, Evans and Stobie mines, to illustrate the ratios between the nickel and copper contents of the ore:

	Copper Cliff.	Evans.	Stobie.
Cu	4·31	1·43	1·92
Ni	5·57	3·74	2·36

A division of value is effected in the ore simply by screening. Thus at the Evans Mine it is found—

	Per cent. Cu.	Per cent. Ni.
The coarse ore carries	1·62	3·45
The raggings	2·99	3·90
The fines	3·78	5·04

The ore is sorted by hand into four grades—1st, the average mixed ore (nickel-copper); 2d, copper pyrites; 3d, pyrrhotite or nickel ore; and 4th, gangue. The closeness with which this separation can be made is shown by the following results:

	Cu per cent.	Ni per cent.
Mixed Ore:		
Copper Cliff	5·67	4·75
Stobie	2·21	2·28
Evans	2·60	4·00
Picked Copper Ore:		
Copper Cliff	14·13	2·74
Stobie	15·71	1·28
Evans	13·86	1·34
Picked Nickel Ore:		
Evans	0·80	8·12
Copper Cliff	0·49	5·36
Average diorite rock	0·80	0·70

This table shows that the pyrrhotite carries the principal nickel value, in comparison with which the chalcopyrite is quite lean, and that these ores are not intimately admixed.

The report of the Ontario Bureau of Mines shows that 8 mines operated by four companies produced 35,790 tons of ore, which probably cost about $5 a ton to produce in 1891. The whole lot averaged 2·62 per cent. nickel; therefore the nickel in the state of ore cost about 10 cents per lb.

The cost of succeeding operations to produce one ton of nickel oxide, containing 76 per cent. of metallic nickel, may be estimated to be $140.74 dealing with these pyrrhotite ores. Its mining and transport can be reckoned at 10 cents per lb.; conversion into oxide, 9 cents; reduction into metal, 8 cents; and allowance for loss in working, 4 cents; total, 31 cents per lb.

Vogt endeavors to trace a constant ratio between nickel, pyrrhotite and chalcopyrite occurring in ore deposits in certain rocks, stating that while in each mine the ratio may vary from day to day, the ore ratio over a long period will give constant results. He gives a table showing the ratio for eight of the principal mines in Norway and Sweden. In them the copper contents corresponding to 100 parts of nickel vary from 20 to 80 and average 43; while the nickel and cobalt contents in 100 parts pure pyrrhotite vary from 2·5 to 7·5, and average 3·8. Thus he claims for ores produced by a segregative process, from one and the same eruptive, such as norite, there is a ratio between the proportion of nickel to copper on one side and the absolute nickel contents of the pure pyrrhotite on the other. The higher the nickel contents of the pyrrhotite, just so much lower is the ratio of copper to nickel. This phenomenon cannot have occurred by chance, but results probably from the relation existing between the small contents of Cu and Fe held in the silicates of the original eruptive magma.

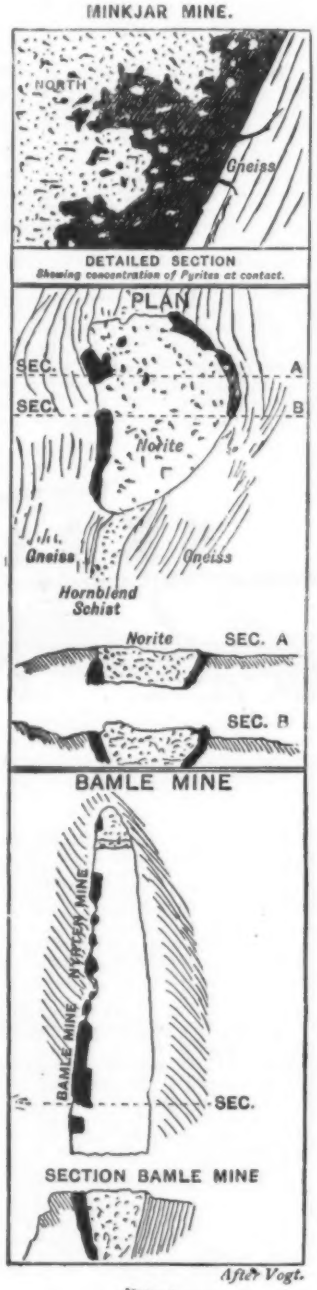


FIG. 1.

Mr. Browne has determined that the nickel exists in the pyrrhotite of the Copper Cliff and Evans ore, chiefly as pentlandite (Ni Fe) S, two-thirds of it being in this mineral form, and he ascribes the enrichment of the ore in depth to the increased amount of pentlandite found in the pyrrhotite of the deeper levels. He claims that the finer grained the ore is the more the nickel exists as an element, replacing the iron in the pyrrhotite, while experience has shown that the coarser grained the ore, and the deeper it lies below the surface, the more it occurs as pentlandite with the pyrrhotite.

S. H. Emmons (New York *Mining Journal*, December 24, 1892) describes three new nickel minerals which he discovered in the Sudbury ore, viz., *folgarite*, found at the Worthington mine, having a composition represented by the formula NiS FeS; *blueite*, discovered in the workings of the Emmons Company's mines, composition NiS_2 ·12 FeS_2; and *whartonite*, found at a mine 7 miles southwest of Sudbury, supposed to have the composition NiS_2 7 FeS_2.

In the Gap Mine of Lancaster County, Pennsylvania, we have another example of a nickel-sulphide ore, consisting of millerite associated with pyrrhotite, impregnating a lenticular mass of hornblende rock, embedded in mica-schist at or near their planes of contact. It has been suggested that this hornblende mass may prove to be an altered eruptive, while it is not unlikely that an adjoining trap dike had some influence in the formation of the ore body.

According to Blake, the ore runs 1·5 to 2 per cent. Ni, while Wharton averages it from a series of his analyses at 3·6 per cent. Ni and Co and 0·75 per cent. Cu.

For a third example, we may turn to the Norwegian pyrrhotite deposits, in which the ore occurs chiefly at the contact of the eruptive norites (massive hypersthene gabbros), with the archean country schists.

It has been pointed out by Stephen Emmons and others that the plane of contact between eruptive and sedimentary or metamorphic rocks offers a favorable passage for the circulation of mineral solutions.

A section of the Minkjar Mine (Fig. 1) represents a familiar ore deposit of this type, such as is usually assumed to have been so deposited. The norite body, shown in the general plan, is 243 ft. long by 135 ft. wide, and is almost entirely surrounded by an irregular deposit of pyrrhotite from 3 to 6 ft. thick. The detailed section illustrates the transition from a normal norite, first into pyrrhitiferous norite, and afterward into almost pure pyrrhotine, concentrated on the immediate contact of the gneiss, into which small veinlets occasionally branch off. Ore bodies are also found in the norite, along the contact of included masses of schist.

The third or silicate group of nickel deposits are best represented by those of New Caledonia, which have been described recently in a paper read by Mr. J. Garland before the Institute of Mining and Metallurgy, and by other writers.

Mons. Heurteau, I believe, made a detailed geological survey of the island in 1873, which led to mining operations being commenced.

The base of New Caledonia seems to consist of a light-colored non-fossiliferous schistose rock, on which secondary and tertiary rocks rest, and about one-third of its area appears to be covered by massive serpentines, which are most prominent in the east and southeast parts of the island.

According to Mons. David Levat (study of the deposits of Ni, Co and Cu in New Caledonia, *Association Francaise pour l'avancement des Sciences*, Paris, 1887), the nickel occurs solely in the form of magnesian hydrated silicates of a beautiful apple green color when pure, as coatings or concretions, in the fissures of the serpentine; and he concludes, from the absence of arsenides or sulphides of nickel, that their mode of occurrence points to the deposition of the ore from solution, in the state in which it is now found. The pure mineral, he reckons, often averages 26 per cent. Ni, but the average ore, after sorting, does not carry over 10 per cent. mixed with some serpentine gangue. Garland puts the average quality of the ore shipped to Europe at only 7 to 8 per cent. of metallic nickel, stating that ore of less than 6 per cent. is considered unmarketable and cannot be sold. The darker green the color of the silicates, the richer the ore seems to be, some specimens appearing to shade off into almost pure silicate of magnesia, which are almost white, containing only traces of nickel. Mons. Peletan has found cleopters inclosed in crystals of the green silicate.

This green silicate is not, however, the only form in which nickel ore occurs in the district, as most valuable deposits are found of a brown mineral of nearly the same composition, which Mr. Garland states is generally the richer of the two. It seems to consist of green silicate, in which part of the magnesia is replaced by hydrated oxide of iron (limonite) which gives it this brown color. Treated with dilute hydrochloric acid, the iron is dissolved out, leaving the green mineral garnerite, which shows that the iron is not chemically combined, but merely mechanically associated with it. The deeper brown it is, the richer the ore is reported to be. This is remarkable, and points again to the fact before remarked, that association with iron appears to affect the nickel contents of the ore in a favorable way. This brown ore has a very light specific gravity, only 3·00, and Claudet gives an analysis of it as follows:

Oxide of nickel (= nickel 9·64 per cent.)	12·25	per cent.
Oxide of iron	32·20	"
Magnesia	3·07	"
Alumina	3·62	"
Silica	34·80	"
Water at 212° Fah.	6·43	"
Water above 212° Fah	7·07	"
	99·44	"

The percentage composition of both the green and brown minerals varies greatly, and the above analysis may be presumed to be below the average, as Garland states that, omitting minor constituents, the average of 12 analyses of the green garnerite made by Prof. Liversidge shows SiO_2 44·75, NiO 19·73, MgO 15·25; and the government year book for 1891 states that the richer mineral has sometimes the following composition: Silica, 45; nickel, 26, magnesium, 13; iron, 3; water, 13. I am also informed by Mr. Gregory that he found millerite in a sample of the ore from New Caledonia.

According to Levat the massive serpentine itself contains nickel in proportions varying from 1 to 3 per cent., and in some cases even 5 per cent. He further inclined to the belief that the protoxide of iron of the serpentines diminishes as soon as the nickel appears in them, and the total of the two metals remains constant, but when his paper was written he had not had the benefit of a microscopical examination to determine this. He lays great stress on the fact that the nickel ores, though found exclusively within the serpentine area, are not distributed there in an arbitrary manner, but always occur at, or in the neighborhood of, certain beds of red clay (vasques), which Mr. Garland describes as looking in the distance like huge scars on the face of the hills. Levat says they appear black in the center and red at the edge, when seen in the distance from the sea, and they are often ranged one above another like stairs on the flank of the hills, giving a most characteristic profile. The former observer, however, denies their argillaceous character, stating that they contain practically no alumina, but consist almost entirely of iron and silica, with 1 to 3 per cent. of nickel, and he gives two analyses in proof of this contention.

The existence of these basins of red clay, or earth, as

they might perhaps (from what has been said) be more properly called, is certainly a most curious feature in the geology of New Caledonia, scarcely less extraordinary than that of the red pigs, for which the island is said to be famed, and possibly the color of the latter may have some connection with the presence of these red deposits on the island. So much of the island appears to be colored red by nature that it seems quite a pity in fact it is not red on the map.

The clays or earths are believed by Levat to be the products of the hydrothermal decomposition of the serpentines, as they contain all the elements of these rocks, in addition to iron, manganese, chromium, and cobalt. He supposes that numerous iron and manganiferous springs found vent through fissures in the serpentine and have eaten it away, leaving half dissolved masses of so-called sugar rock in the clay that fills the basins, which in many places are capped by a deposit of oolitic iron ore, the product of the overflow of the ferruginous waters. Mr. Garland's observations that the ore is found in massive pieces in botryoidal, mammillated, and occasionally in stalactitic forms, and in brecciated masses, supports this view. It has been pointed out also as a remarkable fact that these deposits are mostly found at high altitudes (the mountains of the interior rising to a height of 5,576 feet, and averaging 1,640 feet), and in the lower-lying serpentine areas they are non-existent, but I think it is capable of explanation, if we suppose that the serpentines are the altered products of volcanic action which overflowed in the interior of the island, as it is just there that the conditions would be found most favorable for the deposition of the minerals we have under review, under such circumstances. Veins of chrome iron ore also occur in the hard unaltered serpentines of New Caledonia,* while cobalt ore is likewise found in the red earths, the origin of which latter deposits is considered by Levat to be essentially hydrothermal. The chromium, on the contrary, he thinks, pre-existed in the serpentine, and was derived from it, while the nickel solutions only appeared after the deposition of the clay.

These solutions, circulating not only on the contact, but in the cracks and joints of the adjacent serpentine, would explain the deposition of the hydrated silicate of magnesium and nickel, in "Stockwerk form," which is the most usual mode of occurrence. The nickel ore is, however, also largely found, according to Levat, in a brecciated form on the roof or walls of the basins of red earth, being sometimes symmetrically deposited, when the axis of the basin is vertical (in which case the ore is of equal thickness on the walls); at other times the axis of the basin is inclined, and the serpentine which forms the roof is fissured, the cracks so found being often several meters wide, filled with rich ore, the nickeliferous solutions, being unable to penetrate the clay, finding a natural passage along the walls of the cavities. Where the circulating waters moved for a long time between the walls and the clay, fine striæ are found upon the latter (*Annales des Mines, second livraison*). Levat further states that the nickel deposits lie in a series of zones, running northeast and southwest, starting from the east coast, penetrating into the interior, and continuing, as Mr. Garland points out, to the west coast; outside of them there are only local encroachments, which lack uniformity.

Though in 1887, at the time Levat examined them, the deepest workings were only down 275 feet below the outcrop, he concluded that in depth they would lose their thickness, basing his opinion on the probability that the red earths with which they appear connected would not hold down to any great depth. Levat summarizes the general characteristics as follows: 1. The ore is essentially dependent on the serpentine of the east and southeast parts of the island. 2. Ores of cobalt, associated with manganese, are found in beds on the rim of the basins of the earth found traversing the serpentine in a number of places. These cobalt ores do not contain over two or three per cent. of Co, but they are very extensive, being mined simply by scraping up the material. 3. The deposits of chromium are of two kinds, either in veins in the serpentine or in stratified beds in the basins of earth. 4. The nickel deposits are of later formation than either of the two preceding ones, and are situated exclusively at or in the neighborhood of the contact of these clays or earths with the serpentine, and never in the body of the former. They are united in a certain number of northeast and southwest lines, the width of which does not exceed, as before said, 600 meters.

The crystalline dialage, being less attacked than the other constituents of the serpentine by the mineral solutions which have eaten it away, forms a skeleton, which is sought for by the miners as an indication of ore.

True lodes appear to be absent, but some of the fissures filled with ore can be traced for considerable distances along their strike, possess regular walls and dip, have a width of 18 inches to 5 feet, and have been followed down, in one instance, to a depth of 360 feet below the surface outcrop.

As the formation of the deposits in the basins of red earth is due, Levat thinks, to the shrinkage of those clays, their continuity in depth may probably depend, as he supposes, on the depth of the clays in the basins. It must not be supposed, however, that these deposits are likely to be speedily exhausted, as they have a very wide distribution indeed. They are mined in open quarries, in benches, when found as stock works; at other times, by tunnels and winzes. The work is commenced by removing the red clay, which, if mixed with the ore, entails difficulties, as the grains of iron are with great difficulty separated by washing, and consequently appear in the matte produced. Moreover, the clay, being very aluminous (according to Levat), renders the siliceous ore still more refractory.

The gravity system of transport on a single rope at these mines is certainly extremely primitive, but is no doubt due to the necessity of frequently shifting the position of the terminals. It might, however, be improved upon by hauling up the empty bags and carriers on a carriage attached to the main cable by means of a small hoisting rope, operated by a windlass, instead of carrying them up, as is now done, on men's shoulders. The principle of using gravity inclines with double ropes has been satisfactorily employed underground at the Pierrefitte mines in the Pyrenees, in large open gunnices; the only instance I know of where such a system has been operated underground. It was introduced because the flatness of the lode would have involved shoveling, and it possesses obvious advantages over an inclined plane, for a short temporary roadway in lofty workings.

According to Mr. Ph. Argall (quoting, I believe, from official sources), the output of nickel and cobalt ore from New Caledonia, in 1890, was 22,690 tons of (say) 10 per cent. nickel ore and 2,200 tons of 3 to 5 per cent. cobalt ore, while, in 1891, the output of nickel ore had only reached 35,000 tons. Mr. Garland states, on the other hand, that these mines are now producing over 60,000 tons of nickel ore per annum; and to reconcile the two statements, I take it that he alludes to the crude ore. He puts the cost of mining at 6s. to 40s. per ton.

The first mechanical treatment of the ore consists of sorting and washing at the quarries, where a division is made into rich ore, carrying 8 per cent. and over of nickel, and poor ore under that amount. The ore is then carried to the plain below to be washed, so as to remove the red clay. The nickel has the same specific gravity as the serpentine, but less than the iron. The ore rejected at the quarry, although it contains 3 or 4 per cent. of nickel, is of no value. Garnier's first idea was to treat the ore in a blast furnace, to obtain crude nickel and refine it; but this latter process presented such difficulties that it was abandoned. Fusion for matte was then tried but was also given up, owing to the high price of fuel and the inefficiency of the convict labor. The cost of producing metallic nickel, dealing with such ores, appears to be—mining and transport, 10 cents; conversion into oxide, 3 cents; reduction into metal, 8 cents; allowance for loss of working, 1 cent; total, 22 cents.

(*To be continued.*)

* At the Gasconne mine the serpentines are particularly rich in chromite, occurring in veins in the undecomposed rock, but breaking off suddenly at the contact of the serpentine and clay.

THREE YEARS IN A COUNTRY GAS WORKS.*

By S. M. HIGHLANDS, of Clinton, Iowa.

I DO not think it is possible for me to add anything new to the gas industry, but I have long entertained the idea that the business was hedged around with too much mystery, and that the very conservatism that has been allowed to grow around it was one of the greatest drawbacks with which it had to contend. In the smaller cities the gas superintendent is alone, and in many places very lonely; and he is very apt to think his business a mysterious one; that he is the only man in the community who can master its intricate details; that all he has to do is just to wait until people come to their senses about the electric light craze, and everything will be serene.

It occurred to me some years ago that this was all a mistake; that educating the general public against their convictions is a slow and unprofitable proceeding; and that gas is only a commodity that people can either use or dispense with without very much inconvenience. And further, that the same methods that are most successful in other lines of business could be used to push the sales of gas, and with equal success. I fully believe that the unparalleled growth of the electric business was because of the efforts to make it popular, without regard to any immediate profits.

Infused with these ideas, I assumed the management of the Clinton (Ia.) gas works on April 1, 1891. The works were the usual 6 inch coal gas works and were built in 1871. In 1875 they sold 5,500,000 feet of gas. In 1884 it had increased to 6,122,000 feet. In 1886 the Thomson-Houston Company built an electric light plant and the sales of gas dropped to 5,892,000 feet, and in 1890 it had risen again to 6,491,000 feet, with the price of gas ranging from $2 to $2.50 per 1,000.

On April 1, 1891, the price was reduced to $1.75 for illuminating and $1.25 for fuel; and a contract was made for a set of water gas apparatus. At the outset of the new management, the old adage, "The money was made or lost in the retort house," was totally disregarded. The only aim was to make the kind of gas the public would use the most of, without much thought as to whether the gas was 16 or 24 candles, or whether it took 4 or 5½ gallons of oil, or 35 or 50 pounds of coal to the 1,000 feet. We believed then, as we believe now, that the principal duties of a gas manager were to sell gas, and that the making of it was a minor incident connected with the business; that the margin between the cost in the holder and the usual selling price was so great (greater by far than in any other large, legitimate business) that a manager could easily afford to have the cost increased by 10 to 15 per cent., if by so doing he could devote more of his time to selling it and thereby increase his sales. I will venture the assertion that there is not one manager here who believes he is selling one-half the gas the community would take and pay for, if he could only make it to their interest to do so.

In carrying out this idea, we advertised that for a year we would run free service pipes; sell gas stoves at cost; pipe buildings free; and in a great many places we furnished gas fixtures free. At this time the company had only 235 meters set and not a gas stove in use. By May 1, orders began pouring in on us until we had from 15 to 25 gasfitters at work, and during the summer sold 185 stoves and set 392 meters for illuminating purposes. This work cost the company about $4,000, and you can judge for yourselves whether it is worth this sum to add 577 new customers to a plant that only had 235 to begin with. By September 1, we felt strong enough to tackle the electric light company, and thought a fight with them would advertise us, if nothing else. We sent a canvasser to all their customers and offered to furnish them with gas for a year for half the price they were paying for electric light, generally allowing the customer to say how many gas jets he would need to properly light his place. They had 53 customers, and we took 45 of them on this proposition and had them tied up for one year. This action on our part forced them to sell out to us at once at our price, and we failed to have any fun out of the scheme at all. We metered the 45 contract customers just as carefully as we did the regular ones and took the statements monthly. It might be as well to state here that these contracts raised a new question in our minds that we will take up some time and settle to our own satisfaction at least.

Please remember that all this occurred in a small town, where the manager could be personally acquainted with each of his customers and know what they were doing; and this article is supposed to be of no benefit to the larger cities. Those 45 contract customers were put on without any idea of making very much money out of them, but rather to force a fight on the electric company. We knew when we took them that some of them would get pretty cheap gas, and we were not disappointed. During the year for which they run, they used 2,894,000 feet, for which they paid $2,171.06, or 75 cents per 1,000. In December they used 600,000 feet; and in July, 122,200; one of the largest customers fairly heating his building with it, and paying only 40 cents per 1,000, while some of them were paying as high as $1.50 per 1,000.

We bought the electric light plant in December, 1891, and immediately reduced the price of electric lights 25 per cent., making the rate for arc light of 2,000 candle power $6 per month, for 9 o'clock lights, and $8 for 10 o'clock lights, the gas contract customers having the option of surrendering their gas contracts and taking the electric light at the new price; but none of them availed themselves of the privilege. At the end of the year none of the contracts were renewed. About one-half of them are now using gas and the rest have returned to the electric light.

We found a great many customers who thought they could afford to use a gas stove, but were afraid to try gas for illuminating purposes; and for such customers we always put a gas burner over or near the stove and connect it with the stove meter. The result was that in a short time the man of the house would come to the office and say that he was tried of sitting in the kitchen to read, and wanted one light in his sitting room; and this was followed by several more in other parts of the house at the illuminating rate.

Our office is kept open from 7 A. M. to 9 P. M., and all complaints are taken care of within an hour of their being made. A meter prover is kept in the office; and when a customer thinks his meter is wrong we ask him to wait and see it brought in and tested. We are always willing to settle with him on the basis shown by the prover. I have yet to find the customer who was not perfectly satisfied after seeing this test made, and agreed with us that if there was anything wrong with his bill, the fault was at his house and not in our office.

Another imperative rule is that while we now have a monopoly of the lighting business, our customers should not find out that we know it; they should always be treated as courteously as they are in any other mercantile house; a trivial complaint should be treated with as much consideration as the most serious one. Another rule that will have more weight with them than all others is, whatever we do must be well done. Nothing temporary allowed, and never a makeshift.

In rebuilding the gas works, money was not spared to make it a good one. In rebuilding the electric light plant, the very best Corliss engines and high grade boilers were used. The results are that "no gas" complaints are rarely, if ever, heard, and we have not had a claim for rebate on account of "electric light out" for over two years. Our electric service has been so good that the city has just closed a contract with us for all their street lights for a period of 12 years, and the electric street railroad has contracted with us for its power for 7 years.

There have been no changes in prices on the gas for 3 years; and for the past 2 years we have been charging a fair price for all service work, also for all electric wiring and renewals. In the meantime, the growth of the gas business has been much more rapid than that of the electric business.

As I stated before, the company sold 6,491,000 ft. of gas to 235 customers in the year 1890. In 1891 they sold 11,432,000 ft. to 627 illuminating and 185 fuel customers. At this time—January 1, 1892—we had 50 commercial arc lights and 800 incandescent ones. For the year ending January 1, 1893, we sold 18,000,000 ft. of gas (an increase of 64 per cent.) to 940 customers, and in the year ending January 1, 1894, our sales of gas had increased to over 20,000,000 ft. to 977 customers; while the electric lights had only increased to 65 arcs and 1,200 incandescents, exclusive of the street lighting. With the street lighting and street railroad work, the gross business of the electric light plant is larger than the gas business, but is, of course, a great deal more expensive to us to furnish. On the whole, we are satisfied that proper business methods will push the sale of gas just as readily as that of any other commodity, and that without it the gas business is apt to cut a very small figure in small cities.

As some of you probably know, we also supply gas to Lyons, a city of some 7,000 inhabitants, immediately adjoining Clinton. Lyons has a municipal electric light plant that also supplies domestic lights. This plant has been established some 10 years, while the gas mains were only run 3 years ago. At the time we extended the gas mains there, nearly all the stores and shops were using the electric light. We did not make any effort to displace the electric light, but instead concluded we would see what a fair competition between gas at $1.75 per thousand and arc lights at $5.50 each per month would result in. For the first year or so we did not do a great deal of business with the stores. A customer would use the gas through the summer and then put back the electric lights in the winter when the evenings were long. In the summer of 1893 we sent 50 Welsbach burners up there to see what they would do. We equipped one large jewelry store with them at our expense and then waited for results. And they have been surprising, indeed; for to-day there is not one store in the city using electric lights, the Welsbach burners having entirely displaced them; but at the same time it has cut down our sales of gas, and I do not know but that we had better let a few of the electric lights come back, if we can only get rid of the Welsbach burners. The burners are all that is claimed for them, and give our customers unqualified satisfaction; but the confounded things won't let any gas through them. The same jewelry store that was formerly using two arc lights only used 3,000 ft. of gas in December. After our experiment with them at Lyons, we would prefer furnishing electric lights rather than Welsbach burners in Clinton.

* A paper read before the Western Gas Association, Cleveland.—*American Gas Light Journal.*

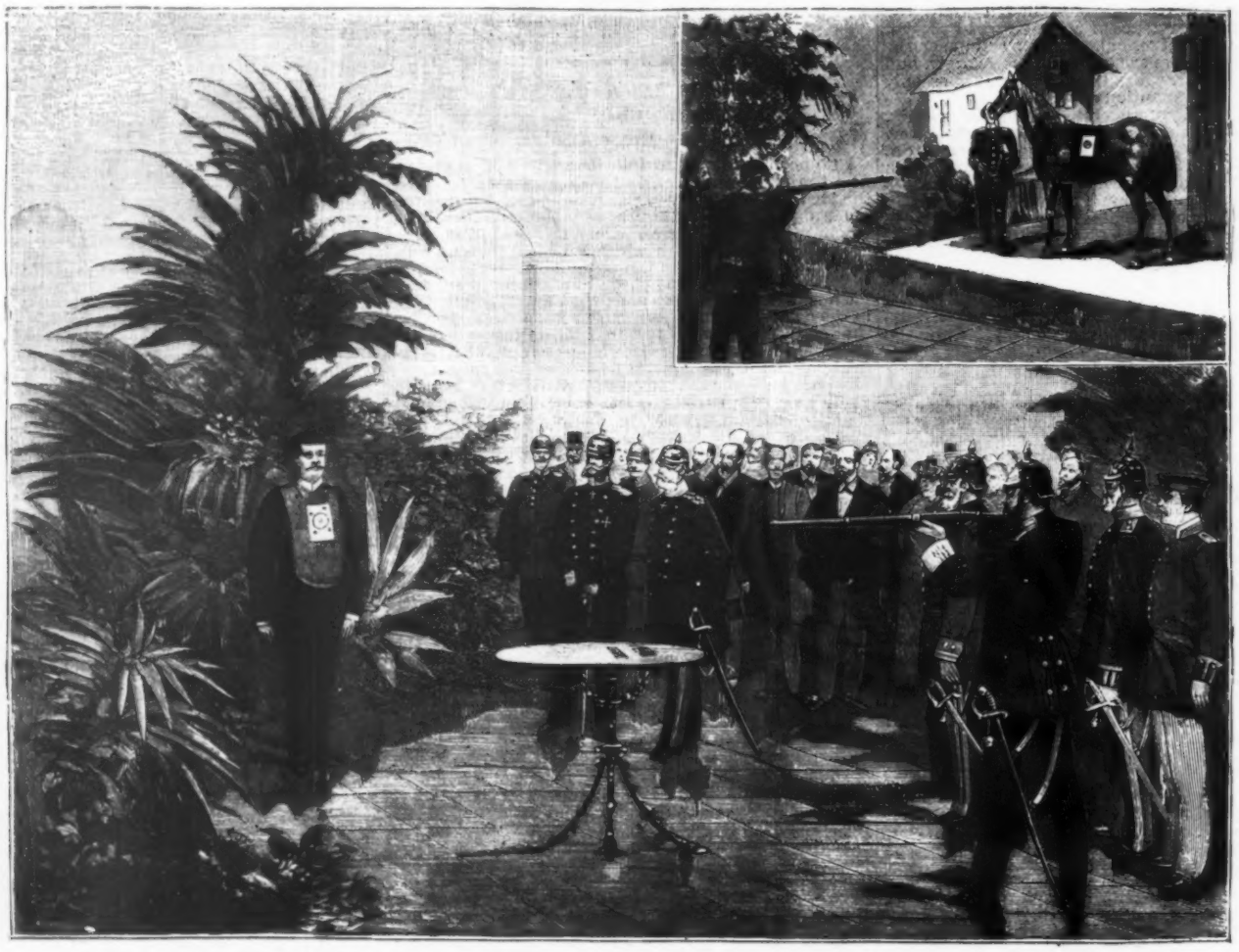
BULLET-PROOF JACKETS.

OUR illustration (for which we are indebted to *La Ilustracion Española y Americana*) shows the trial which took place in the Winter Garden, at Berlin, on the 8th of April last, of bullet-proof jackets invented by Mr. Dowe. Many generals and army chiefs and the ambassadors of other countries were present at the trial. Rifleman Martin first discharged his gun against a horse covered with bullet-proof cloth. The animal received several charges without moving; not one of the bullets touched him. Afterward several soldiers loaded their muskets with regular charges, fired against a bust of plaster, which was protected with the cloth, and the bullets did not cause the least damage. Finally, the inventor himself covered his breast with a bullet-proof handkerchief of his invention and allowed himself to be shot at several times without being injured. Our picture shows this scene. The bullet-proof cloth, the dimensions of which can be seen in the engraving, weighs 18 pounds, but the inventor affirms it may be reduced one-half in weight; the thickness is two-thirds of an inch.

The Emperor William has shown great interest in this invention, and has promised to be present at some new trials.

Since Mr. Dowe's successful exhibits, Mr. Hiram Maxim, of London, has produced a bullet-proof jacket of analogous character, which he claims weighs even less than the German article.

Bullet-proof jackets have been made with steel plates inclosed in cloth. They are similar in general idea to the bullet-proof screens or boarding nets for war vessels, invented by Mr. Midgely, of Beaver Falls, Pa. These screens will arrest bullets fired from ordinary rifles, and thus give a protection to men on the decks of war vessels when in action.



THE RECENT TRIAL OF DOWE'S BULLET-PROOF JACKETS, AT BERLIN.

VARIOUS USES OF WOOD.

THERE are countless ways in which wood is being consumed, besides the larger uses for fuel, building purposes, and the like; and in the aggregate these unconsidered uses amount to a serious drain upon the forests, while little or nothing is done to insure a supply for future demands. The enumeration of the special uses of wood in the arts forms a very interesting chapter. One of the principal uses of the wood of the holly, dyed black, is to be substituted for ebony in the handles of metal teapots, etc., and the strong, straight shoals, deprived of their bark, are made up into whip handles and walking sticks. The limetree forms the best planks for shoemakers and glovers upon which to cut their leather, and is extensively used in the manufacture of toys and Tunbridge ware, and by the turner for pill boxes, etc; and the inner bark is made into ropes and matting. The sycamore furnishes wood for cheese and cider presses, mangles, etc., and when the wooden dishes and spoons were in common use they were mostly made of this wood. It is now used also in printing and bleaching works for beetling beams and in cast iron foundries for making patterns. The yew is used by the turner and made into vases, snuffboxes and musical instruments, and it is a common saying among the inhabitants of New Forest that a post of yew will outlast a post of iron. Where it is found in sufficient quantities to be employed for works underground, such as water pipes, pumps, etc., the yew will last longer than any other wood. Gate posts and stakes of yew are admirable to wear, and in France the wood makes the strongest of all wooden axletrees. Of the beech are made planes, screws, wooden shovels, and common fowling pieces and muskets are also stocked with it, and beech staves for herring barrels are not unknown. The sweet or Spanish chestnut furnishes gate and other posts, railing, and barrel staves, hop poles and other such matters, such as strong and good charcoal, though scarcely equal to that of oak for domestic purposes, but considered superior to that of any other for forges.

Hornbeam is the best wood that can be used for cogs of wheels, excelling either the crab or the yew; but its application in this manner is about at an end. As a fuel it stands in the highest rank, emitting much heat, burning long, and with a bright, clear flame. In charcoal it is highly prized, not only for culinary purposes and the forge, but also for the manufacture of gunpowder, into which, on the Continent, it enters in large proportion.

In Russia many of the roads are formed of the trunks of the Scotch pine, trees from six inches to one foot in diameter at the larger end being selected for the purpose. These are laid down side by side across the intended road, the thick of one alternately with the narrow end of the other, and the branches being left at the end to form a sort of hedge on each side of the road. When thus laid the hollows are filled up with earth, and the road is finished, being analogous to the corduroy roads of North America. In Germany casks are made of larch, which is almost indestructible, and they allow of no evaporation of the spirituous particles of the wine contained in them. In Switzerland larch poles are much used for vine crops, they are never taken up, and see crop after crop of vines spring up, bear their fruit, and perish at their feet without showing symptoms of decay. The uninjured state in which larch remains when buried in the earth or immersed in water renders it an excellent material for water pipes, to which purpose it is largely applied in many parts of France. The butternut is esteemed for the posts and rails of rural fences in America, for troughs for the use of cattle, for corn shovels and wooden dishes.

Shellbark hickory provides baskets, whip handles and the backbows of Windsor chairs. The pignut hickory is preferred to any other for axletrees and ax handles. The sugar maple is used by wheelwrights for axletrees and spokes, and for lining the runners of common sleds. Dogwood is used for the handles of light tools, such as mallets, small vises, etc. In the country it furnishes harrow teeth to the American farmer, and supplies the harness of horses' collars, etc.; also lining for the runners of sledges. The mountain laurel is selected for the handles of light tools, for small screws, boxes, etc. It most resembles boxwood, and is most proper to supply its place. Bowls and trays are made of red birch, and when saplings of hickory or white oak are not to be found, hoops, particularly those of rice casks, are made of the young stocks and of branches not exceeding one inch in diameter. Its twigs are exclusively chosen for the brooms with which the streets and courtyards are swept. The twigs of the other species of birch, being less supple and more brittle, are not proper for this use. Shoe lasts are made from birch, but they are less esteemed than those of beech.

Immense quantities of wooden shoes are made in France from the wood of the European alder, which are seasoned by fire before they are sold. The wood of the locust is substituted for box by the turners in many species of light work, such as salt cellars, sugar bowls, candlesticks, spoons, and forks for salads, boxes, and many other trifling objects, which are carefully wrought into pleasant shapes and sold at low prices. The olive is used to form light ornamental articles, such as dressing cases, tobacco boxes, etc. The wood of the roots, which is more agreeably marbled, is preferred, and for inlaying it is invaluable. Of persimmon turners make large screws and tinmen's mallets. Also shoemakers' lasts are made of it equal to beech, and for the shafts of chaises it has been found preferable to ash, and to every species of wood except lancewood. The common European elm is used for the carriages of cannon and for the gunwales, the blocks, etc., of ships. It is everywhere preferred by wheelwrights for the naves and fellies of wheels, and for other objects. White cedar serves many subsidiary purposes. From it are fabricated pails, wash tubs, and churns of different forms. The ware is cheap, light, and neatly made, and instead of becoming dull, like that of other wood, it grows whiter and smoother by use. The hoops are made of young cedars stripped of the bark and split into two parts. The wood also supplies good charcoal. The red cedar furnishes staves, cigar boxes, stopcocks, stakes, and is also used for coffins.

A few special applications of wood in this country are mentioned, separated into trades—namely, sieves, usually of black or water ash for the bottom and oak or hickory for the circle; whipstocks, white oak; baskets, willow, white oak and shellbark hickory; picture frames, white pine and sweet gum; saddletrees, red maple and sugar maple; screws of bookbinders' presses, hickory or dogwood; hatters' blocks, sour gum; corn shovels, butternut; shoe lasts, beech and black or yellow birch.—*Carpenter and Builder.*

AN AMATEUR'S PHOTOGRAPHIC LABORATORY.

WE very frequently receive letters from readers who write us that they wish to practice photography, and ask us to tell them what is the best apparatus adapted for a beginner, and what are the simplest, surest and best methods for the experiments to be made. Our correspondents are assuredly not aware of the difficulty of answering such questions. What is the most suitable apparatus? Well, the number of photographic apparatus has no limits; they are of all sizes and of all prices, from ten dollars up to a hundred. What are the methods? A description of these would be so extensive that it would form treatises of several volumes.

Still, we are anxious to give our readers information when they apply to our journal. An enthusiastic practician for many years past, we shall tell them what apparatus we employ, and describe to them the arrangement of our little laboratory and the preparations that we use therein. Coming into frequent contact, at Paris, with the most skillful operators, we have had recourse to their experience, and it is through following their advice that we have methodized matters. Beginners who wish to learn as amateurs will be able, we think, to imitate us with some profit. It is unnecessary to say that we have no other pretension

than that of guiding the first steps of those who ask for the first principles.

What apparatus shall we make use of? The photographic apparatus should be neither too large nor too small. Get an objective of fine quality, and do not look at the price too closely, for good results are obtained with good apparatus. Complete the objective with a shutter for taking instantaneous photographs. Employ sensitized plates of the first quality. Good instruments and good brands are now very numerous, and it is necessary to use them.

For an exposure during a promenade, we select the

FIG. 1.—AN AMATEUR'S PHOTOGRAPHIC LABORATORY.

view that is most pleasing to take, with a good supply of light, the sun being behind us. If the sun is shining, we take an instantaneous view with a $\frac{6}{10}$ inch diaphragm and a rapid exposure. If the sky is leaden, we make an exposure of from one to three seconds, according to the extent of the landscape, and of about three seconds for a group of persons taken at a few yards' distance. After the impression of the plate, we come to its development.

The method of development that we have followed since our debut is the pyrogallic acid one. It is excellent, and permits of turning almost all negatives to account. It is well known and has been several times described by Mr. Albert Londe. It is as follows: Pyrogallic acid in powder, one mustard spoonful; concentrated solution of sulphite of soda and water, half and half; concentrated solution of carbonate of soda, a thimbleful; and bromide of potassium, a few drops. If the negative is deficient in intensity, we add some pyrogallic acid; if it is wanting in details, we increase the proportion of the carbonate of soda; if it comes out too quickly and we wish to moderate the development, we add some bromide of potassium. It requires much carbonate of soda for instantaneous photos, and very little for long exposures. After the development comes washing under a faucet, and fixing by means of a 30 per cent. hyposulphite of soda bath. The negative may be left in this without detriment, even after the fixing is finished. Next comes washing with a large quantity of water in a circulation tray.

The 5 × 7 inch apparatus needs a foot, and the carriage of it is sometimes inconvenient on somewhat lengthy walks. The amateur will do well to have another hand apparatus for instantaneous photography. We have successfully employed several apparatus in a

FIG. 2.—DEVELOPING APPARATUS.

trip through Switzerland. There are many excellent systems, but we cannot enumerate them all. With instantaneous apparatus, the amateur will do well to operate only under a sunlit sky. The results are often defective when the sky is overcast.

Our laboratory is modest in size. It is in a small Mansard room, but there is nothing wanting in it as regards equipment. It is darkened by means of a spring roller blind, which effects a hermetical closing. It is provided with a lantern having red and yellow glasses, and that contains a small kerosene lamp. The water enters through a cock above a sandstone sink provided with a constant-level safety closer. A second cock, terminating in a rose, permits of obtaining a shower of water for washings. Fig. 1 shows the appearance of this little laboratory. To the left we see the sink with its two cocks, and on one side the fixing and alum baths,* and on the other side the lantern and the developing bottles. In front of the window is the washing trough. The part of the laboratory not shown in the engraving comprises a laboratory furnace with its hood and its gas apparatus, and a table with scales, one of which is an instrument of precision. The tables are formed of enameled volvic lava, an excellent product and a very valuable one from the view point of laboratory cleanliness.

Fig. 2 shows the developing accessories. For holding the solutions, we use bottles provided with glass labels. A yellow glass jar contains the pyrogallic acid. The tray that we use is placed upon a rocking board that permits of agitating the developing liquid. Alongside of the pyrogallic acid jar is the wooden spoon that permits of dipping out the liquid. Near the tray we observe the hooked nippers that serve for lifting the submerged negatives, and alongside stands the graduate used for preparing the developing bath.

We recommend amateurs to exercise much care and cleanliness in the laboratory, and to let there be no upset liquids or stains. With dexterity it is possible to develop with pyrogallic aid without blackening the fingers.

We repeat, in concluding, that we give here only the methods of a practician who confines himself to an installation for an unpretentious amateur. The reader who wishes to devote himself to photography will perhaps find therein a few data useful for his debut.—*Gaston Tissandier, in La Nature.*

GOLD MOIRE-METALLIQUE.

By A. LIVERSIDGE, M.A., F.R.S., Professor of Chemistry in the University of Sydney.

IN experimenting upon the reduction of gold from solution, to test the theories of the formation of gold nuggets, I found that the pure gold plates and foil which I used in many cases presented a moire metallique appearance, such as is so familiar to us in tin plate and galvanized iron. The whole surface of the plate became dotted over with more or less regular crystals like those often seen on tin plate; they are, however, much more regular and rectangular in outline and very small, the majority being less than one mm. square.

Afterward I found that this crystallization could be brought about by merely boiling the pure gold foil or plate in hydrochloric acid. The acid, although free from nitric acid, dissolved traces of the gold, probably due to a little free chlorine.

This moire-metallique gold may have been observed before, but I have not come across any reference to it. Advantage might be taken of it for decorative purposes on jewelry and other articles made of gold plate.—*Chem. News.*

* It is not a bad idea to immerse the negative in an alum bath before putting it into the hyposulphite solution.

NOTE ON AN APPARATUS FOR THE CONTINUOUS PRODUCTION OF NITRIC ACID.*

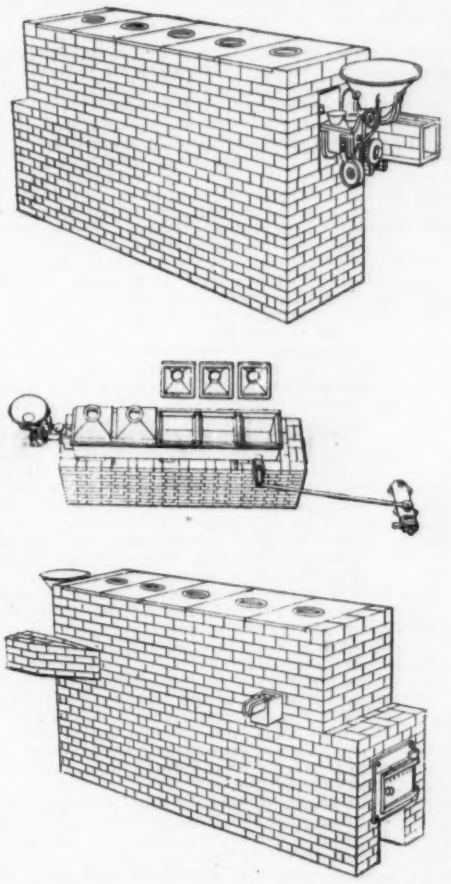
By MANNING PRENTICE.

BY the kind invitation of the committee I have the honor to exhibit a model of the apparatus designed to produce nitric acid in a continuous manner.

As long ago as 1878 I carried to a very satisfactory issue experiments in the continuous distillation or rectification of sulphuric acid. The system of platinum pans which I invented was soon adopted by the largest makers of oil of vitriol, both in Europe and America, and the Prentice pan holds its own, in my opinion, to this day.

The great saving in fuel and general convenience of a continuous process is now so well recognized that you will not be surprised to learn that soon after patenting my platinum pans for the concentration of sulphuric acid, I began experiments with the object of discovering some method by which nitric acid could be produced without the loss caused by the alternate heating and cooling which occur in the ordinary process.

The difficulties seemed, however, insurmountable, and it was not until 1892 that I again took up this question and discovered important points which enabled me at last to solve the problem.



The model before you is an exact copy of the apparatus which has been working satisfactorily at Stowmarket for some time.

The nitrate of soda is placed in weighed quantities into the hopper, whence it passes (in the same manner as grain runs in a flour mill) to the feeder. This feeder is a miniature horizontal pug mill, which receives the streams of acid and of nitrate, and after thoroughly mixing them delivers them into the still, where, under the influence of heat, they rapidly become a homogeneous liquid, from which nitric acid continuously distills.

The still is divided into compartments or chambers in such a manner that the fluid may pass continuously from one to another. The nitric acid being continuously separated by distillation, the contents of each division vary—the first containing the full proportion of nitric acid and each succeeding one less of the nitric acid, until from the overflow of the last one the bisulphate of soda flows away without any nitric acid.

I may point out that while the ordinary process of making nitric acid is one of fractional distillation by *time*, mine is fractional distillation by space.

Instead of the operation being always at the same point of space, but differing by the successive points of time, I arrange for the differences to take place at different points of space, and these differences exist during one and the same points of time.

Experience has shown that there may be considerable variation made both in the proportion of sulphuric acid used and also in its strength, enabling one to obtain the nitric acid from the different still heads of varying strengths and varying proportions of acid of these varying densities. This is useful to those makers who require different acids for differing trade purposes.

It is also quite possible to produce the full product of nitric acid of the full gravity of 1.500.

* Read before the Society of Chemical Industry.—From the *Journal*.

With regard to the saving effected by my system, it has been found to exceed my expectations.

I now save more than two-thirds in fuel, also save four-fifths of the condensing plant.

One of my stills, capable of producing about four tons of nitric acid per week, weighs less than two tons; whereas (to produce the same quantity) two stills weighing five tons each were formerly used.

This saving of four-fifths of the weight of iron is accompanied by a corresponding saving in the cost of masonry.

There is also reason to believe that the life of my new still will be ten times greater than that of any previous still, for the destruction of the stills has been due to the alternate heating and cooling, with the consequent condensation of acid vapors within the still. This is, of course, entirely obviated by my continuous process.

I hope that my work in improving the process of production of nitric acid may be as useful to the makers of nitric acid as my improvements in the production of oil of vitriol have been to the makers of sulphuric acid.

HOW TO LIVE AND RETAIN HEALTH AND VIGOR IN OLD AGE.

By NICOLAS PIKE.

THE casual observer cannot but ask himself the cause of so many sudden deaths of persons of both sexes, in middle life, which are reported every day. The mortality of late years has been extraordinary. To the mind of the writer it is easily accounted for, and as easily corrected; it is owing to the habits of life civilization has led people into, to the want of exercise, the inattention to the functions of the skin, the late hours of going to bed, and a long string of etceteras—all of which produce a lax, irritable condition of the membranes and fibers of the body, and a gorged state of the vascular system; a habit of body which is highly susceptible to the action of physical causes, and may be said to have a predisposition to run into disease, or which produces a full, plethoric habit of body that is little less so. If you wish to have health, it is necessary that you should be regular in your habits, have a stated time for your meals, eat sparingly of plain, nourishing food and leave pastry alone, abstain from ardent spirits and tobacco, retire from the dinner table feeling a little hungry; bathe often, and exercise in the open air when you can, as breathing the pure air gives life and strength; retire to bed early, as a good night's rest gives the body a chance to recover the nervous wastes lost during the waking hours. There is no doubt but sleep is a prolonger of life, and is upheld in a recent medical work on the digestive organs and faculties. The duration of human life may be ascertained by pulsation of the body. Say a man lives to 70 years, his heart beating 60 to the minute; the pulsations in that time foot up 2,207,520,000. If by intemperance or any other cause he raises pulsation to 75 a minute, the same number of pulsations is less in a sleeping than a waking state; it stands to reason that a long sleeper has a much better prospect of long life than a person who is satisfied with naps. It is well known that the great cause of our bodily ailments is repletion, that is, eating a larger quantity of food than is wanted to supply the necessaries of the system. A large number of persons are confined indoor, factories, counting houses, and workshops, with little or no exercise, and are deprived of the influence of a pure and unadulterated atmosphere. Such persons should pay great attention to diet, and should live in the plainest and most simple manner, taking but little of animal food. This will counteract the evils resulting from the mode of life they follow. The man or woman who is working at laborious, heavy work, breathing the pure air, would require a large quantity of solids to even sustain him; he could not do without it, as the nervous strain of the body requires it. The stomach then becomes the principal seat in which all ailments begin, which radiate through the whole system—a very essential thing, and one that can hardly be too much urged upon the attention of the thoughtful.

There is no doubt in my own mind that heart disease, Bright's disease of the kidneys, and many other diseases of a kindred nature, which are common at the present day, are caused by too much animal food. Our grandfathers and mothers, who lived to a good old age, subsisted on the plainest food, and were regular in their habits. They took time to eat and masticate their food; they were abstemious, and seldom made use of ardent spirits, with few exceptions. They were healthy and strong, and never indulged in late suppers or late hours. Fifty years ago, heart disease was seldom recorded. Why? Because their manner of living was plain, simple, and regular. Bread and butter, oatmeal cake, sweet milk, weak coffee, furnished their breakfast; sometimes boiled eggs. This was all. Their dinner was oftentimes pork and beans, with a good bread pudding or boiled rice. For supper, toast and tea, oftentimes oatmeal porridge. With this diet they worked all day on their farms, in shops and offices, and seldom called in a doctor.

They were strong and healthy. Look at the contrast at the present day. The breakfast in a fashionable and wealthy house is quite an elaborate affair. The dinner, with a course of many elaborate and made up dishes to tickle the palate, with wines and liquors of the choicest kind, strong coffee, with liqueur and cigars to terminate the banquet of three or four hours' duration.

At these gatherings wines and liquors are taken freely by both sexes. Now, as it is well known that alcohol acts on the human system as a stimulant, and excites all the organs of the body into preternatural activity, makes the heart beat quicker and stronger, causes the blood to be driven more rapidly through the system, and a greater flow of the various secretions for a time, so long as its influence lasts; when it is expended, there is none of its strength left to nourish or support the body, but, on the contrary, a degree of languor or exhaustion remains, as the consequence of the excitement that had preceded it. The stimulus has exhausted the vital energies, the nervous system is robbed of its power, and the mind, which depends on the nervous system for the manifestation of its powers, which is linked intimately to it, which is strong when it is healthy and ill when it is disordered, which sympathizes constantly with the state in which it is—the mind suffers, the mental powers pay the penalty of the wrongs inflicted on their material organs, of the goading and lashing to which they have subjected them. It excites and stupefies and indirectly wears out those who indulge in its use.

Is there any wonder that these gentlemen of leisure, who ride everywhere they go, and seldom take exercise, die suddenly? You can answer this question as well as myself.

The female part of the community who lead this life of pleasure, who indulge in late hours at balls and private parties, die a premature death; if married, bring forth puny children, who also die early. It is terrible to think of! A celebrated physician of New York once remarked in my presence that the wealthy men of New York would be obliged to marry with other races in order to perpetuate the species, as the present generation were fast dying out on account of their mode of life. This I believe, and I base my opinion on personal observations which I have noticed in families I am acquainted with.

In order to retain vigor in old age, one must take care of themselves when young. If you abuse nature, she will remind you of it in the downhill of life. Why do we see hearty, healthy old gentlemen, who have retained all their faculties at the age of 60 or 70? Such persons are frequently met with, who might pass for gentlemen of 50 years. If you should ask them to give you a brief history of how they have lived, they would answer, "Regularity in everything! in eating and drinking, plain and wholesome diet; early to bed and early to rise, abstain from all fermented drinks, and discard tobacco." It is very difficult to lay down a *menu* of what should be taken at breakfast, dinner, or supper, or how it should be taken. There are, however, general rules, and many kinds of foods which nourish the body generously. First it is absolutely necessary to be regular. Have a stated time for breakfast, dinner, and supper. Eat nothing between meals; do not wash down every mouthful of food with liquid of any kind. If you do, it will bring on indigestion. Always drink after you have eaten, if you require it.

Vegetables of all kinds are wholesome, and should be taken freely with your dinner. Fruit should only be taken at breakfast, and never at any other time. This is an old custom in the East, which has been followed for centuries by the Chinese and East Indians, and where dyspepsia is unknown.

The more the stomach has to do in a given time, the less will it be fitted for further work; and if to a certain point and for a moderate time it has been allowed to repose from its labors, it will be in a much fitter condition for the exercise of its powers. Hence many articles of diet are digested without inconvenience when eaten in the morning, or in the earlier part of the day, that would by no means agree with the stomach if taken in the after part of the day, or in the evening. The best time for eating fruit is, therefore, for more reasons than one, in the morning or forenoon; at breakfast, or between that meal and dinner. During sleep, the earlier stages of digestion are much hurried, and the latter stages coming on prematurely, are performed imperfectly, and often with much inconvenience, and at times with no small disturbance to the system. Hence it is at no time more imprudent to eat fruit than at supper, or worse, just before going to bed. The greater the amount of actual vigor that the system possesses, the more easy and quick will be the digestion of food. The more exhausted the bodily powers, the more likely an article of food will be to disagree. Hence the very worst time at which fruit can be eaten is when the individual is fatigued; when the powers are exhausted, no matter how, whether by mental labor or bodily exercise or excessive heat. By attending to these points, it will be found that many can eat fruit with impunity and without risk who could not otherwise have done so. But there is an essential thing still to be mentioned, one that can hardly be too much urged on the reader's attention. It is that the quantity eaten be moderate; be rather less than the stomach could take without inconvenience than more than it could comfortably digest. The skins and seeds of fruits should never be eaten.

It is well to take meat only at dinner, and this meal should be taken in the middle of the day.

I will give an account of a few old people I have interviewed, and their mode of life, in my opinion, is the cause of their longevity. *Miss Hermond*, aged 102 years. The faculties of this lady were remarkable, eyesight, memory, and general health excellent. She stated that, when a girl, she lived on a farm, attended a country school till she was fourteen. Her father being a farmer, she worked home, milking cows, making butter, and doing general work about the house as a helping hand to her mother. Her mode of life was very regular. The whole family retired to rest soon after supper, and at the break of day could be found at their work in the house and about the farm. Breakfast at 7 o'clock, and consisted of oat and wheat cakes, butter and milk; sometimes fresh eggs, boiled or fried. *Dinner* always at 12 o'clock, which consisted of boiled or roast, sometimes fried meat, with all kinds of vegetables, which they used freely. Twice a week salt or fresh fish was served. A pudding, made of bread or rice, was the standing dish for "dessert." Sometimes pancakes were served. *Supper:* Bread and milk, milk toast, milk or weak tea. The only pastry they ever used consisted of pumpkin and apple pies. Pork and beans, with a suet pudding, was generally placed in the oven on Saturday night for Sunday's dinner, as her father and mother would not have cooking done on Sunday.

The above was the manner in which she lived for more than 70 years. Fruits which they raised were used freely by the family. The last twenty years of her life she has used oatmeal and other cereals for her breakfast; no coffee or tea—only warm milk.

This remarkable woman never called a doctor but two or three times in her life, and her sickness, she says, has always been owing to her own indiscretion, thinking she could do in her old age as she could when young.

Captain H. W. Morton, aged 97. This old gentleman was born near Marblehead, was hale and hearty, would row his dory a distance of a mile every day, to the fishing banks, without experiencing any fatigue. His faculties were excellent and his eyesight good; step regular and firm, voice clear, and might easily be taken for a well-preserved man of 70. He stated to me that his occupation had been that of a fisherman for 84 years. He had been a temperate man, both in eating and drinking, all his life. He was seldom sick, but had enjoyed good health since he was born. His food was simple and his habits regular; he was fond of sea food, which he made his principal diet, with a generous supply of vegetables of all kinds. Meat he seldom made use of. His meals were always taken at regular hours: breakfast at 7, dinner at 1 o'clock, and supper at 6. He retired to rest at 9 o'clock, and rose at daylight. He never called a doctor but once in his life; then it was to bandage his arm, broken by falling on the ice.

There is a gentleman in Brooklyn, 77 years of age, who is remarkably well preserved. He walks on an average six miles every day, when the weather will permit, and during the last year walked from Carlton Avenue to 103d Street and back, without feeling fatigue. To Coney Island and back is a morning's walk with him, when the weather is brisk and clear. For years he has accustomed himself to exercise in the open air, and has always preferred walking to riding. He is seldom sick, and, as a general thing, has enjoyed health nearly all his life, which has been a regular one, retiring early in order to give the body a chance to recuperate the nervous waste lost during waking hours. He is of the opinion that one hour's sleep before midnight is worth two hours afterward. Rising early in the morning gives one a chance to take the day by the forelock, whereby more work can be accomplished. Breakfast at 7 in the summer, in winter at 8 o'clock. This consists of oatmeal, well cooked, about 22 ounces in weight, with two soft-boiled eggs; a glass full of warm milk was all that was ever taken at this meal. *Dinner at 1 o'clock.* This consisted of fresh fish and all kinds of sea foods, which he prefers; beef and mutton (the latter preferred) was served about three times a week; not more than 4 or 5 ounces of this was taken at one meal. Game and poulty in the season and vegetables of all kinds were used in abundance. Rice or bread pudding for "dessert." Baked beans were served on Sunday for dinner, with rice pudding. Supper at 6 o'clock; oftentimes this meal was bread and milk; toast and *weak* tea or hot milk and water. No food of any kind was taken between meals. Coffee seldom made use of, as in early life it was noticed that it thickened the blood and accelerated the action of the heart. It is well known that anything that does this shortens life. Ardent spirits have been seldom used; smoking tobacco in early life, occasionally. In fact, the whole life of this gentleman has been temperate, frugal, and industrious.

M. Francisque Sarcy, the great Paris critic, has recently become a vegetarian, and feels the better for it. He says he is only a "moderate vegetarian," that is, he only eschews meat and admits eggs, butter, cheese, milk, and fish into his *régime*. Contrary to the expectation of both himself and his friends, he finds that he is in much more vigorous health and in better working condition under the influence of his new daily *menu* than before. At first he felt hungry an hour or two after eating, but after fifteen days the craving for meat passed away, and now he not only eats at the same hour as before, but consumes much less. The advantages of the diet are, he says, most remarkable. His mind is clearer, and his body more disposed for work; is no longer sleepy after meals, his brain is fresher, his limbs more elastic, and, more astonishing still, he has great resistance to fatigue. Formerly he felt the need of stimulants, now he has suppressed "*les petits verrs.*" He does not smoke, and he is even endeavoring to diminish the quantities of coffee which he has been in the habit of taking. Altogether, he is very enthusiastic, and closes his dietetic confession by asking others to try his system.

It is the opinion of many of our scientists and medical men that the present generation dip too deeply into the flesh pots, or, in other words, eat altogether too much meat. Bright's disease of the kidneys and heart disease are, in the opinion of many, caused by this. We have, as an example, cases where animals are fed altogether with meat. They are not only short-lived, but are subject to diseases that man is heir to. Dr. Jaggar says the almost universal habit of feeding dogs with raw meat and to restrict house dogs to vegetarian diet, although such is not their natural diet, it might be supposed that the unnatural nutriment would disagree with them—but precisely the reverse is the case. Those fed on meat are in no way healthier than those fed on vegetable diet; on the contrary, the former have a disposition to eruptive diseases, digestive complaints, inflammatory disorders, hemorrhoids, and do not live long. It is a well known fact that many tribes of North American Indians are great consumers of flesh, and the result is, they are short-lived. They are subject to many diseases; smallpox sweeps away thousands of their number; kidney, lung and liver complaints are very common with them—diseases which hardly ever occur with the large rice-eating population of the East, or others who make a generous use of vegetable diet. Moral as well as physical life is largely directed by the food we eat, and it is safe to say that three-fourths of our bodily ailments and diseases are the legitimate results of improper dietetic habits. It is a physiological fact that our blood is made from the food we eat, and it is easy to understand that perfect food will create perfect blood, and may thus become the most effective medicine. It is generally admitted by authorities on the subject of diet that nitrogen is the most essential of all foods, and that a certain quantity should be taken daily. It appears that the diminution in quantity of food most frequently affects the nitrogen. Meat is the article of diet which, as a rule, is the source of the greater part of needed amount of nitrogen. At all events, meat is the popular article of food. Care, however, should be observed that too much even of this should not be consumed.

The substance most necessary for the preservation of life—the albuminoids—hold the foremost place, and the different kinds of fibrin, albumen, casein, are capable of taking the place of each other. The animal kingdom contains these substances in much greater abundance than the vegetable kingdom, but we can derive them from both. The herbivorous animals concentrate the albuminous substance of vegetables, and present to us nutrient matter. It is generally admitted by good authority on the subject of diet that nitrogen is the most essential of all foods, and that a small amount should be taken daily. The gray portion of gluten in wheat is a vegetable albminoid, differing in

no essential particular from the albumen of eggs and flesh, and is, consequently, rich in those nitrogenous and phosphatic elements which are equal to the repairs of the brain and nervous system and the muscular tissue. All foods we eat belong to one of the four following divisions: 1st. The starches. 2d. The fats. 3d. The albumens. 4th. The salts.

Dr. Sheppard says the uses of foods in the human economy are three: *First*, to build up and maintain the various tissues which compose it; *second*, to sustain the temperature at a proper degree; and *third*, to supply energy and force of action. The chief materials of supply for these three ends may be classified as: *First*, nitrogenized elements; *second*, hydrocarbonates; and *third*, carbohydrates; which, together with some inorganic principles, furnish all the requirements of foods.

In the last ten years I have interviewed more than fifty persons, male and female, that have arrived at the age of 90 and upward. Ten per cent. of these were over 95, and all of them, without a single exception, have been very regular in their habits. Plain food, such as they raised on their farms, was used—very little meat, and this only in the middle of the day, when the principal meal was taken. In all the interviews I have had with these old people, not one of them used much animal food for breakfast or supper, except eggs. Fish, butter and cheese—never pork, beef, or poultry. The cereals, such as oatmeal, wheat flour, rye and Indian meal; sometimes rice, when they could get it; milk, always in abundance, was on the table. Vegetables, which they raised on the farm, were always cooked and used freely. Also fruits of all kinds. Nearly all were temperate men and women; many never tasted spirits of any kind, and very few of the men ever made use of tobacco. All, without a single exception, retired to rest never later than 9 o'clock, and were early risers. Two-thirds of the number were brought up on farms, which they tilled; nine were professional men, doctors, ministers, and lawyers, who followed the manner of living which was taught them when young. Eight were fishermen, who were on the water a great part of their lives. By observing carefully the food taken by these old ladies and gentlemen, it will be seen that it was of such a nature containing a large supply of nitrogenized elements, which, together with some inorganic principles, furnish all the requirements of food. This, together with an active, regular, and temperate mode of living, is the cause, in my opinion, of their longevity.

[Continued from SUPPLEMENT, No. 963, p. 15393.]

THE ADULTERATION OF FOOD.*

By H. W. WILEY, Chemist of the United States Department of Agriculture.

Sugar.—The common idea that the grocer puts sand in his sugar is not borne out by the facts in this country. I doubt whether a single pound of white sand has been put into the sugar supply of this country in the last ten years. It is one of those popular fallacies which gain credence inversely proportional to their truth. The granulated and white lump sugars which are found in our markets are almost absolutely pure; as pure indeed as the utmost care in manufacture can make them. Occasionally a little flour or starch may find its way into the powdered sugar, but such instances must be exceedingly rare. Low grade sugars contain molasses and water as a result of the way in which they are made and dried. In the refineries, after the pure white sugar has been secured, the molasses therefrom is reboiled and a second crop of sugar crystals obtained. These form the so-called coffee sugars of commerce. In a like manner a third crop of rather light colored crystals may often be formed. By a combination of low temperature and high vacuum in boiling, and by a manipulation producing small crystals, a sugar can be made very soft, and, so prepared, it absorbs a good deal of the mother liquor in which its crystals grow. It is possible, in this way, to put on the market a fairly light colored and attractive sugar which may not contain more than eighty-five per cent. of pure sugar. This process of making low grade sugars is practiced chiefly with the product of the sugar cane. In sugar from beets the molasses and mother liquors are usually so highly charged with alkaline salts as to render the manufacture of low grade sugars, fit for table use, a very difficult matter. In this country, as is well known, the greater part of the sugar consumed is made from sugar cane. Of the 4,000,000,000 pounds which we have eaten in the last twelve months, probably 3,500,000,000 have been grown under tropical suns. The proportion of yellow, coffee and low grade sugars offered is, therefore, greater in our markets than in Europe, where the sugar beet supplies nearly all the sugar consumed.

Sirups.—In respect of molasses and sirups the bill of health is not quite so clean. The quantity of pure maple sirup sold annually is well calculated to make the maple forests of Vermont prick up their ears. A very little maple molasses mapleizes the whole jugful; a fact that makers and sellers have not been slow to learn. An extract of hickory bark imparts a misleading flavor to a sirup made from cane sugar and starch, and a patent has been granted by the United States protecting the discoverer of this process in the exercise of his invention. Judicious mixtures of glucose, sugar, sirup and maple flavor are the secrets of the marvelous expansiveness of maple molasses between the tree and the gullet.

"Golden drips," "honey sirups," etc., are names given to compounds made of refinery refuse, glucose and centrifugal cane molasses. The great base of all our table sirups is glucose made from corn starch. I am far from denouncing glucose as a dangerous ingredient in such mixtures. On the contrary, when glucose is properly made, it is both palatable and wholesome, but its sale as maple molasses or as refiner's sirup or as open kettle molasses is clearly fraudulent.

Honey.—Liquid honey is very largely adulterated with glucose. Of five hundred samples of honey bought in fifteen large cities and examined by the Chemical Division of the United States Department of Agriculture, nearly forty-five per cent. were found to be fraudulent. Of comb honey, only that is adulterated which comes in bottles or jars. A few years ago there was a popular impression, which I shared, to the effect that comb honey in the frame was adulterated, but no sample of this kind has ever come under my observation, and I am convinced that such a species of adulteration does not exist. Perhaps there is no class of food producers in the country whose business has been so seriously injured by adulteration as the bee growers. Many of them, however, do not seem to realize the magnitude of the frauds which are perpetrated against them. They have often been known to denounce, as attempts to injure their business, the statements that such frauds are practiced. Of late, since indubitable evidence of fraud has been presented to them, they have determined to use every means to end it.

Coffee.—Almost equally subject to adulteration is ground coffee. The high price of coffee is a special incentive to sophistication. In former days it was largely the custom to buy the green berry, and each consumer would do his own roasting. Now it is fashionable, not only to buy the roasted berry, but also to buy it in a ground state. Chiccory, roasted peas, beans, etc., are often found in large proportions in such preparations, and, in fact, it is somewhat rare to find a pure ground coffee. It might be held that such sophistication would end with the ground article, but such is not the case. The berries themselves have been imitated both in the green and in the roasted state. The moistened mass of chiccory, starch, pea meal, caramel, molasses, etc., is moulded into the proper shape, and, when dried, these imitations might easily escape detection when mixed with the genuine berries. Those who are so fortunately situated as to be permitted to live at home and regale themselves each morning with an aromatic cup of Mocha or Java scarcely realize what it means to drink a lukewarm concoction of chiccory and pea meal, bluish black in color, but decidedly yellow in flavor.

Tea.—Thanks to our customs laws very little tea is found in this country adulterated with foreign leaves. The chief adulterations practiced with tea are found in the use of spent leaves and in the practice of facing. The practice of facing consists in treating the leaves with some preparation designed either to increase their weight or to improve their appearance. Salts of iron and copper are often used for this purpose. Some of these facing materials are quite prejudicial to health, and such teas are best excluded from the breakfast table.

Cocoa.—Cocoa and chocolate are largely adulterated with starch and sugar, harmless in themselves, but far cheaper than the meat of the *Cocoa theobroma*. The natural oil of the cocoa bean is also often extracted, and its place supplied by a cheaper fat or left without an oil. These various preparations are offered under fancy names and with wonderful claims of excellence. But in general we may say that the food value of a preparation is not much improved by having it digested before it is eaten. Yet often we see it claimed for a given mixture that it has had all of its difficultly digested components removed and that these are replaced by others with which the gastric juice can have a veritable picnic. The digestible cocoas often belong to this class, and, perchance, may have little of the virtues of the original beans left in them.

Canned Foods.—Of canned foods I should like to say something, but it is difficult to select the little which can yet be said. First of all, the material of which the cans are composed is a matter to deserve attention. It is undoubtedly true that glass is the ideal substance for cans designed to preserve food products. But the first cost of these packages and the danger of breakage during filling and transportation exclude them from competition with tin in all except the choicest brands of preserved foods. Fortunately, tin is a metal which is not only troublesome to the tariff, but also resistant to most organic acids. It is acted on very slowly or not at all by most organic acids found in fruits, vegetables and meats. In some countries, such as Germany, the tin which is used in contact with canned foods is required to be almost pure, and to contain not more than one or two per cent. of lead. The most abundant adulterant of tin, as found in tin cans, is lead, and it is against the presence of lead that it is especially necessary to guard, inasmuch as the organic salts of lead, without exception, are poisonous. In this country of personal liberty there is no restriction as to the percentage of lead which tins used for canned foods may contain. We have found as high as twelve per cent. of lead in tin from cans which have contained food designed for consumption. Such a high percentage of this dangerous metal cannot fail to excite alarm. We have also found numerous evidences of erosion on the tinned surfaces exposed to the action of the contents of the can. The contact of the preserved goods with solder should also be carefully prevented, inasmuch as solder contains often as much as fifty per cent. of lead. It is very common, however, to find lumps of solder in the canned goods and also to find the solder protruding through the points of union of the can and cover so as to be exposed to the action of the contents.

Copper in Peas.—Equally objectionable is the habit of using copper salts to impart a bright green color to canned peas and other goods. The imported French peas are uniformly colored with copper. The addition of a little copper, in any vegetable which it is desired to keep green when served, has a happy effect in that direction, and fashionable cooks have not been slow to learn this. It is true that the quantity of copper which one would eat in a single meal where French peas are served would not prove greatly injurious, but on that large part of our population who are compelled to dine every day on truffles and peas interspersed with terrapin and champagne, there is great danger of the copper acting with accumulative effect.

I have already spoken of the danger which may lurk in preservatives, such as salicylic acid, but there is also an occasional source of danger in the development of nitrogenous bodies called ptomaines in preserved meats. These bodies may develop with astounding rapidity if a can of meat be opened, and not eaten for a day or two. An illustration of the fatality of the action of such bodies is unfortunately often found in the case of tyrotoxicon, a poison often developed in milk or cream.

The above will serve as illustrations of the more common forms of adulteration to which our foods are subjected. The idea might be formed from this array of facts that foods are almost all adulterated, and that it is extremely difficult to obtain anything pure. Newpapers love to magnify these accounts of adulteration. What I have placed before you has not been for the purpose of exciting a panic on the subject of foods. Much the greater part of foods which Americans eat is pure and wholesome. It is only the small quantity of adulterated food from which we should strive to protect ourselves. This exaggeration of the adulteration of food has been humorously portrayed by Burdette in a little scrap of rhyme, entitled

A VICTIM OF DELUSION.

Placid I am, content, serene.
I take my slab of gypsum bread,
And chunks of oleomargarine
Upon its tasteless sides I spread.

The egg I eat was never laid
By any cackling, feathered hen;
But from the Lord knows what 'tis made
In Newark by unfeathered men.

I wash my simple breakfast down
With fragrant chiccory so cheap;
Or with the best black tea in town—
Dried willow leaves—I calmly sleep.

But if from man's vile arts I flee
And drink pure water from the pump,
I gulp down infusoriæ,
And hideous rotatoriæ,
And wriggling polygastricæ,
And slimy diatomaceæ,
And hard-shelled orphryocercinæ,
And double-barreled kolpodæ,
Non-loricated ambroilæ,
And various animalculæ;
Of middle, high and low degree;
For nature just beats all creation
In multiplied adulteration.

Even the conservative work of the Department of Agriculture in investigations of food adulteration, which I have had the honor to conduct during the past six years, becomes most highly sensational material when portrayed in the columns of a daily journal. In the *Philadelphia Star*, of recent date, appeared the following remarkable statement of the work of the chemical division:

"Glucose, it appears, is the greatest of all adulterants. It is used for making cheap candy, sugars, jellies and sirups. Apple sauce is pumpkin boiled in cider. It is said that the cheap confectionery and liquors are the articles most injuriously adulterated. Candy commonly contains much fusel oil and other poisons. Strawberry ice cream—a plate of it—often contains almost more fusel oil than five glasses of poor whisky. It is colored with red aniline dye. Licorice drops are usually made out of candy factory sweepings. Wine is frequently nothing but water with a percentage of crude alcohol from grain or the refuse of beet refineries, colored with burnt sugar, flavored with oil of cognac and given an agreeable woody taste with a little catechu. When one buys tea for $1 a pound, one is very likely to pay in reality $2 a pound, because one-half the quantity is currant leaves. Grated horseradish is sometimes composed of turnip. Flour is frequently weighted with soapstone. Sweetened water, sharpened with citric and tartaric acids and flavored with the oil of orange skin, makes orange cider. Real honey can be distinguished, under the microscope, by the pollen grains it contains. They have wonderfully beautiful forms and the very flowers from which the honey was obtained can be identified by the various exquisite shapes of these fructifying germs."

The above startling facts in regard to adulteration, which are attributed to the Department of Agriculture, are worthy of especial notice because not one of them was ever abstracted from any report of the department. Scarcely a single instance of the adulterations mentioned above has ever been observed and reported on by the chemists of the department. Thus it is seen that the popular idea of adulteration is really very much at fault, and this has been due largely to the exaggerated statements of presumably honest men who desire to call attention to the fraud and to prevent it by exciting the popular mind against it. The adulteration of our foods and drugs is certainly bad enough, but in my mind it does no good whatever to exaggerate, falsify and misstate the results of careful and unbiased investigations. As has before been intimated, in this address, the remedy against all these things lies clearly in the power of the people. Wise laws wisely administered, a careful system of inspection, a demand for pure food, will secure the people in their right. It is not the rich for whom we should work, but the poor, and they should be protected against frauds in food; frauds not so dangerous on account of being deleterious to health as because of their pretensions to furnish to the poorer part of our people a food ostensibly pure and nutritious, but in reality valueless. It is not supposed for a moment that any system of legislation can entirely prevent the perpetration of frauds upon the community, but at least these crimes can be made punishable and their perpetrators may be compelled to endure the penalty of their misdeeds.

* A lecture delivered before the Franklin Institute. From the *Journal of the Institute.*

A PLEA FOR THE SUPPRESSION OF VICE.

AT the recent sanitary convention, San Jose, Cal., Dr. Geo. Childs Macdonald read a paper on the contagious diseases and their suppression by legal measures, in which he remarked: "I intend solely to deal with syphilis and the legal measures which could and should be enforced for its extermination. This disease is the most frequent of all human maladies and, although secret, is very wide in its influences, and, therefore, worthy of serious consideration. . . .

"In advocating prophylaxis I do not want you to understand that I am doing so in the interest of those who deliberately expose themselves to contagion—my plea is for those innocent ones who are the victims of cruel circumstances and for the material welfare of ourselves as a nation.

"There are many ways of inoculation, such as kissing an infected person, using the same fork, knife or pipe, sleeping in the same sheets on which a diseased

person has lain, dental and surgical instruments, vaccination, suckling a syphilitic child or an infected nurse suckling a healthy child. . . . Physicians frequently become inoculated by examining diseased patients; rag pickers of necessity are liable to infection, and so on through many and various conditions of life. But my plea becomes stronger when we consider the position of the young wife, the expectant mother and unborn child. It is easy for us to say that no man should marry who has acquired this disease, but how futile our warnings! . . .

"We are advocating the segregation of phthisical patients because of the tubercle bacillus; what of the bacillus of syphilis? Phthisis has slain its thousands, syphilis its tens of thousands. The bacillus of phthisis only attacks the inherently weak, those predisposed to its action. Thus tuberculosis becomes a factor in natural selection by which these weaklings are removed and prevented from propagating their infirmities. It is, therefore, so to speak, a regenerator of the race, while syphilis, attacking strong and weak alike, has no such selective properties, but its tendency is toward human degeneration, physically, mentally and morally. . . .

"It becomes the duty of all honest minded, intelligent men to throw aside a false modesty in this matter and stamp out the pest which we, as a race, have been harboring so many years, and to assist in obtaining legal enactments necessary. Such laws should be divided into two classes, viz.: 1. Those which apply to the community at large, including restriction against the spread of the disease, accommodation for treatment, etc. 2. Those which control the family and individual. Hospitals for this disease should be maintained at the expense of the State, in which these people should be received and kept until non-infectious.

"Every woman known to be a person of ill-fame should be duly licensed. She should be compelled to attend twice a week at some municipal building set aside for this purpose, where she shall undergo a proper medical examination by a physician appointed by the State. He should enter her name, address and description in a book as a means of identification, and indorse her license, such indorsement to hold good until next examination. Should she be found diseased, she should be sent to the nearest State hospital. . . .

"No male should marry or obtain a marriage license until he shall produce before the recorder a certificate from a physician stating that he is not contagious in a venereal sense, and that he has not contracted syphilis for three years past. All wet nurses should before entering on their duties obtain a certificate of health from the certifying physicians. All vaccination should be done solely by calf lymph.

"The system I advocate would bring all kinds and conditions of men under this law. These few remarks are but a nucleus to demand your serious consideration as guardians of the public health."

THE LATEST EGYPTIAN DISCOVERIES.

SINCE the commencement of the century, in Egypt, more than in any other country, antiquaries and archæologists have dug and excavated so as to penetrate the mysteries of the history of the ancient races that peopled the land. The ground has been turned over, more or less, in nearly every district, and many a hitherto forgotten town or city has been brought to light, so that we might say that little has been left undiscovered which was worth discovering in the country between Alexandria and the cataracts on the Nile.

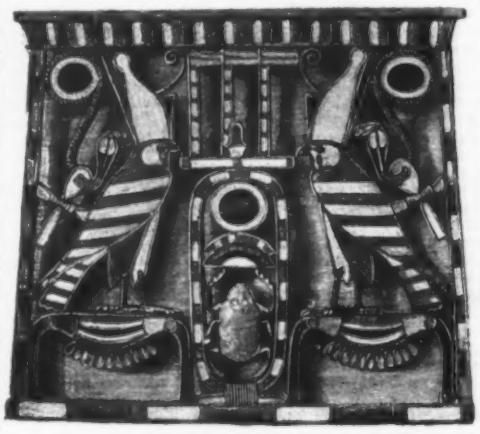
Of all the places in the Valley of the Nile, none has more often attracted the attention of explorers than the tract of country which has been called the Necropolis of Memphis—that spot in the desert which the ancient inhabitants of Memphis chose as a site for the tombs of their rulers, and where the kings of the ancient dynasties erected the pyramids which were to contain their mortal remains. In spite of their efforts to hide the actual position in each instance of the chamber containing the coffin, the iconoclastic explorer of this and other centuries has discovered them in the majority of cases, and the tombs have been rifled of their treasures. Many of the pyramids, as we all know, have contained objects of historical value, which have enabled archæologists to make discoveries of the greatest importance, while some of the other ancient monuments have hitherto added little of any value to the student of Egyptology.

Until recently, the two brick pyramids of Dahchour (or Dashoor) might have been included among the monuments which were full of mystery, and which had hitherto not enriched the stores of nineteenth century knowledge. These pyramids are called by the Arabs the black pyramids, and they have excited the curiosity of travelers from the time of Herodotus, who said of them that they were even more mysterious than their sisters the stone pyramids.

At one time these brick pyramids had an outer covering of stone, but this was taken away by a well-known Egyptan conqueror, the famous Sesostris, who did not hesitate to denude these pyramids of their carved stone facings, so as to enrich and enlarge the beautiful temple of Ptah at Memphis. To-day the pyramids are little better than shapeless mounds, although a close inspection shows how well each pile had originally been constructed, and of what good material it had been composed, to stand so long after being deprived of its protecting stone covering.

So early as the year 1839, Mr. Perring, who had been sent out on behalf of the British Museum, had attempted to cut his way into the more northerly of the two brick pyramids, but without result. The Egyptian government department which concerns itself with the discovery and preservation of Egyptian antiquities, a department founded by the French *savant* M. Mariette, the discoverer of many of the Memphis remains, has made several attempts to probe the depths of the mystery of the "black pyramids," and in 1884, under the direction of Mr. Maspero, an excavation on an unusually large scale was commenced on the north side of the larger pyramid. It was expected that the secret entrance to the innermost chambers would soon be reached. The work was continued for two years and was then given up.

The new director of the department, Mr. T. De Morgan, being satisfied that the efforts of his predecessors had not been properly directed, determined to make a fresh attack on this mysterious and impregnable fortress of the dead. So in February this year he established himself at Dahchour, and shortly after his arrival some hundreds of fellahs were engaged to make excavations. The men dug the sand and filled the baskets for the women and children to carry off, the whole crowd singing all day long their peculiar songs, of which the words vary but seldom and the tune



THE DISCOVERIES NEAR MEMPHIS—JEWELED BREASTPIECE OF THE TIME OF OSIRTASEN II.

THE DISCOVERIES NEAR MEMPHIS—JEWELED BREASTPIECE OF THE TIME OF AMENEMHA III.

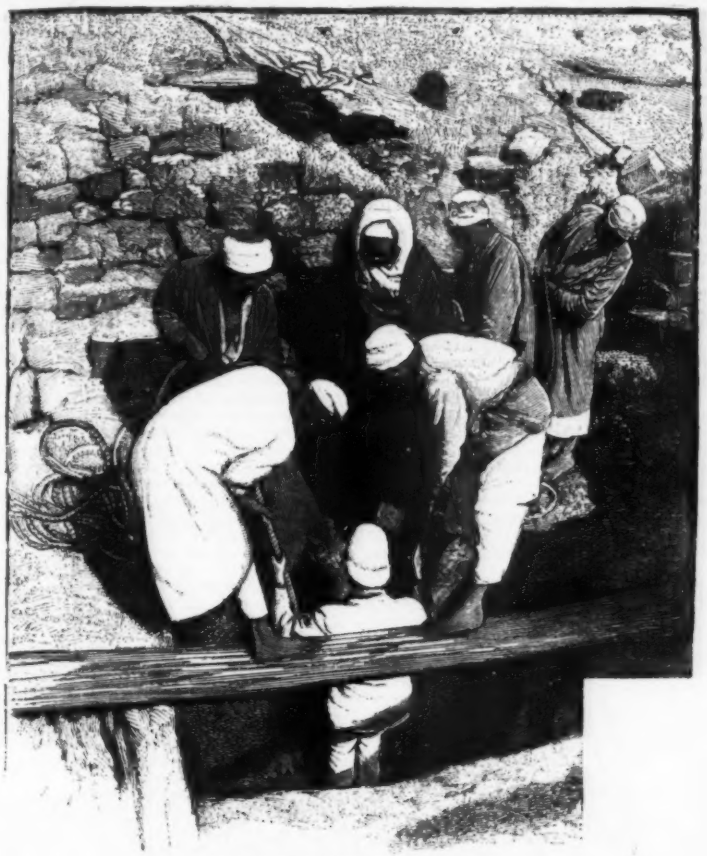
never. Mr. De Morgan commenced by excavating the tombs situated round the pyramid, by which he was enabled to make researches proving the period to which the tombs as well as the pyramids belonged. These tombs were the burial places of the richest inhabitants of Memphis who lived in the reigns of the kings who built the pyramids; the better class of people, and the courtiers, being able to afford to be buried close to the burial place of the kings. About thirty mastabas, as these tombs are called, were laid bare, among them being the sepulchers of several grand court functionaries known to students of ancient history, such as Khnoum-Hotep, Nebasi, and Out-Khent-Khiti. All the tombs were built on the same simple principle each being covered by a mass of stone masonry ornamented on the sides with sculptured funereal figures, while in each case the entrance to the tomb was from the north, whence a passage led to a pit more or less deep, in which the sarcophagus had been deposited. This was, of course, the mode of burial in vogue up to and including the Twelfth Dynasty. Among the royal names on some of the tombs were those of Osirtasen II., Osirtasen III., and Amenemha III., the principal monarchs of that dynasty.

As a result of his researches, Mr. De Morgan was able to prove that the large pyramid was built on a plan similar to the small tombs, for he set his men to dig carefully all along the northern base of the pyramid inside the outer surrounding wall, until one day his enterprise and patience were rewarded by the discovery of an entrance to a pit in which was an opening leading to a tortuous narrow passage. At the end of this passage was a tomb with a rifled sarcophagus—rifled by the spoliators of a bygone age, perhaps in the time of the Romans. This sarcophagus chamber led to a gallery about 120 yards long. The pit by which entry had thus been obtained into the pyramid was evidently not the true and original entrance, but a pit made by the people who had rifled the tomb of its

MR. MORGAN NEAR THE BOTTOM OF THE WELL.

creasure. The difficulty now was to find the proper doorway. And this was all the more necessary since it was found impossible to remain inside the gallery without being suffocated, and an opening near the other end of this gallery would establish some ventilation which would enable the workers to carry on their explorations. At length the proper entrance was found. It led to twelve vaults more or less spacious, of which the contents—sarcophagi, offerings, canopies, carpets, etc.—had been stolen or rifled at some remote period of antiquity. Most of the objects left behind contained no inscriptions; but the few hieroglyphics remaining showed that the explorers were in the burial place of a family of high estate; in fact, of a whole series of princesses, and among them actually the coffin of the Queen Nofert-Hout, and the coffin of the royal daughter M nt-Sent-Senbetes.

But the discovery that placed the date of these burials as having taken place in the middle of the medium or middle empire, during the time of the most powerful dynasty of that period, was made a few days later. Mr. De Morgan was carefully clearing the floor of the passage when he discovered, under the spade of one of his assistants, a hiding place scarcely covered by the sand, and which had not been noticed by those robbers of bygone days who had rifled the tombs. In this secret receptacle was a little wooden box, quite rotten, filled with jewels of perfectly marvelous workmanship. This box was carefully conveyed to the museum at Gizeh. The principal jewel was a breastpiece of gold incrusted with precious stones of remarkable beauty and of very fine workmanship. On this was depicted two eagles guarding the tomb of Osirtasen II. The rest of the jewelry consisted of necklaces, bands, bracelets and scores of various little trinkets.



MR. MORGAN'S DESCENT.

The following day the explorers brought to light, close to the sarcophagus of another princess, a still larger box of jewels, of which the principal were two breastplates, on which are inscribed the names Osirtasen III. and Amenemha III., while around the names the enemies of these two kings are depicted being thrown to the ground.

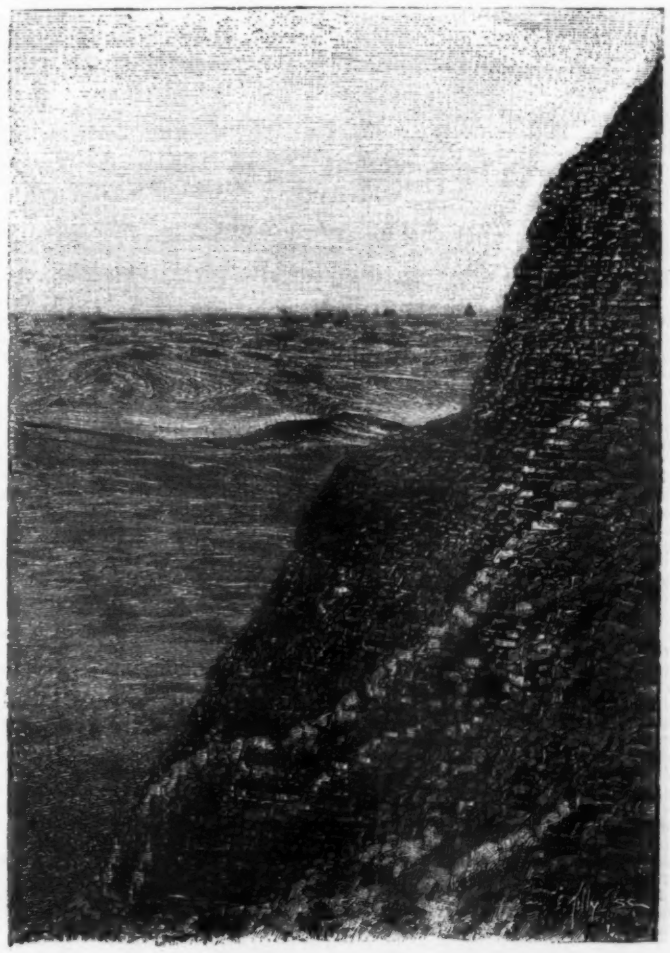
Encouraged by these finds, the explorers continued their researches, but as yet the vault containing the mummy of the king for whom the pyramid was constructed has not been discovered. Success will, however, crown Mr. De Morgan's efforts, which have been delayed by the mass of *debris* caused by the former excavators.

Since the discovery of the great subterranean passage, several other pits have been cleared of sand, but none has given any interesting result. Two fine sarcophagi made of alabaster have, however, been found.

In the meantime, at the other brick pyramid, situated nearly two miles to the south of the first, some important work was being carried on. This pyramid is not nearly in so good a state of preservation as the northern one. Here the work was commenced on the 6th of April, and a series of excavations have been made along the north side, as in the case of the previous pyramid. Some of the discoveries already made will be of great scientific value. The first was the tomb of a king whose name has hitherto been unknown in the compiled lists of Egyptian monarchs. This king's name is Hor Rafou-ab, and his place is at the end of the twelfth dynasty. The tomb also contained a wooden coffin, covered with bands of gold engraved with hieroglyphics, and a statue made of acacia wood, and representing the king. This coffin stood close by and is ornamented similarly to the real coffin. Hieroglyphics cover the gold bands. The statue, which is almost life-size, represents a young man of extraordinary beauty, and is a wonderful example of Egyptian art; in fact, it throws quite a new light on the art of the period.

The next vault had been left intact, and was found just as the mourners left it thousands of years ago, with the funeral offerings surrounding the sarcophagus. A princess had been buried here. Her name was Noub-Hotep, and in the coffin were inclosed jewels of great interest, consisting of necklaces, bracelets, anklets, and other trinkets. A scourge was also in the coffin.

This is how matters stand at Dahchour. The two pyramids have not yet altogether disclosed their secrets, but Mr. De Morgan is quite justified in expecting that success will crown his well directed labors. The value of these latest researches can, of course, hardly be estimated as yet.



SOUTH ANGLE OF THE PYRAMID.

THE LAKE TCHAD CONVENTION BETWEEN FRANCE AND GERMANY.

THE negotiations which have been going on for some time between France and Germany for the determination of the limits of their respective territory in the valley of the Congo and along Lake Tchad were concluded by a convention signed in Berlin on February 4, 1894. The text of the treaty is published in the April number of the *Revue Francaise*. Its articles would probably not interest our readers, but some statements regarding previous transactions and exploration taken from that magazine may be helpful to them in reading the future history of Africa. And there is much likelihood that history may be made rapidly there; for the great powers and the weak ones of Europe are apportioning the continent among themselves in somewhat the same manner that they did the Americas three centuries ago.

The territory concerned in this new treaty lies between the Gulf of Guinea on the southwest and Lake Tchad on the north. To the south and east lies the French Congo territory; to the west, in the valley of the Niger and its branch the Bénoué, are the English possessions. The German territory thus bounded is most singular in shape; it has the form of a pelican, with the head touching Lake Tchad; the beak is toward the east and the neck is formed by the narrow strip between Bifara and Yola. Kameroun and Adamaoua are the names given to this possession.

It seems that in the Anglo-German convention of November 15, 1893, England did a very handsome thing. With that British generosity which is so well known, she gave to Germany some territory which she did not possess, and upon which she made no claim—namely, Adamaoua (except Yola), Baghirmi and Ouadai, with all their possible prolongation toward Oubaughi. It is a large piece, and in their enthusiasm the Germans already saw the flag of the empire floating from the Gulf of Guinea to the basin of the Upper Nile. There was only one obstacle (but it had its weight) to the realization of this beautiful dream, namely, the claims of France, duly established, upon a very important fraction of these lands. England was certainly not ignorant of these claims, but it seems extraordinary that Germany did not appear to be aware of them.

It was not until after the signing of the treaty that Germany, having bought the pelt of the bear, began to ask herself how she could kill the bear to get the pelt. From that time negotiations began with France—negotiations upon which the German delegates, imbued with the spirit of the Anglo-German treaty, entered with considerable claims.

The mission of Nechtritz in Adamaoua produced an analogous effect upon the German negotiators.

This mission was the first which had passed Yola; it had reached there in a boat, in ascending the Niger and the Bénoué. It followed, though very slowly, the course of the Bénoué and of the Mayo-Kebbi, directing itself toward the east. Already they saw it reaching Chari and Baghirmi, thus placing itself between the French establishments of the Saugha River and Lake Tchad. Such were the influences which acted upon the German plenipotentiaries.

If upon the side of Germany there were claims and hopes, upon the French side there were positive facts to present. The *Revue Francaise* (from which this translation is made) has set forth at different times the favorable situation of France gained by its explorers. While De Brazza, methodically ascending the Saugha, effected its final occupation, Mizou, crossing the whole of Adamaoua, from Yola to the Saugha by Ngaoun-

dére, made treaties with the chiefs of the countries which he visited. Then Maistre, going from the Oubanghi to Yola, also treated with all the chiefs of the country, joining again, after Mizou, our possessions in the basin of the Congo with Yola and the Bénoué. . . .

The French delegates were in a good position to negotiate, and the advantage was on their side more than in 1890. However, the basis [of settlement] proposed by Germany at that time finally triumphed, after successive relinquishment of the extreme claims made by both sides. Whatever the German press may say, it is a success for Germany to have obtained not only the territories which were still *res nullius*, but to have seen placed under the sphere of her influence regions which by treaties had been placed under the French protectorate. . . .

In a word, France has completely given up to Germany nearly all the Mizou route situated in Adamaoua and that part of Maistre's route comprised between Lamé and Yola. What does Germany give in exchange for this? Nothing except hopes, and hopes which did not seem likely to be realized soon, though it be granted that the French explorers are considerably in advance of the German explorers in the region south of the Tchad.

One of the great advantages obtained by this treaty seems at first to be the free access to Lake Tchad. Without doubt this has its value; but what profit can Germany derive from it? Will the relations which she can have with Bornou be facilitated thereby? No; for communications will be established with that by land. . . . Access to Tchad is a matter of secondary interest to Germany, while it is of primary importance to France, which could by means of it realize the project of the union of her Algerian, Soudanese and Congo possessions. The essential point in the convention is the assignment of Adamaoua to Germany. Why? Because this region, which is rich, fertile and populated, is also and especially the most habitable and healthiest of all Western Africa, and because it is probably the only one where a European race could settle, become acclimated and grow.

What is Adamaoua? It is a vast plateau situated at an altitude of about 3,250 feet, where a number of groups of mountains lift their summits more than 6,000 feet. It may perhaps be called "the Abyssinia of Western Africa," for it is, like that country, a great reservoir, from which numerous watercourses run to the four points of the compass. The climate is almost temperate, and our agents in the Congo consider it a favorable place for the location of a sanitarium.

From its topographical situation especially Adamaoua will have a great colonial future. Its assignment to Germany is therefore a matter of capital importance, and indeed it is no exaggeration to say that the supremacy given here is the greatest advantage given by the convention. No doubt it is not possible for France to lay claim to all the territory of Adamaoua, the western part of which has been at different times the object of German exploration, but we have a right to claim the eastern part, that visited by Mizou and De Brazza, and to refuse all concession of this part. It is to be regretted that we have not done it.

In the acquisition of territory which the European powers have made in Africa for several years, what they have been obliged to consider first has not been the extent or richness of the territory merely, but the healthfulness and fitness for habitation. Better to own a healthful tract 1,000 kilometers square than one of 10,000 kilometers, however rich it might be, where a European could not become acclimated. . . . .

Let us hope that in the future boundary setting—for there are still many subjects for dispute in Africa—the instructions given to our negotiators will permit them to assert the claims of France in an energetic manner, in order that more ample satisfaction to its interests may be given.

The article by G. Demanche, from which these extracts have been taken, is followed by the translation of an article which appeared in the *Cologne Gazette* soon after the convention was signed. It is an account of the meeting of fifteen men prominent in colonial matters, held at the invitation of the Colonial Department in Berlin. The majority of those present were in favor of the negotiations with France, in view of the impossibility of sending new expeditions, and in view of the fact that the one German expedition of Baron Von Nechtritz cannot counterbalance the numerous results of the French expeditions. The baron's party, it seems, were at that time still in the field with a small body of men, and exploring this almost unknown region as they were, the results were more or less doubtful. However, upon the success of Von Nechtritz's exploration in the direction of Baghirmi, the claim to all Adamaoua and the Upper Bénoué could well be considered safe.

Most of those present at the meeting felt that it was an exceptional time for the imperial government to get some concessions from France without pecuniary returns. Three members of this company, gathered to consider the colonial questions, were in favor of breaking the negotiations with France and of waiting to see the end of Von Nechtritz's exploration, or of sending out a new party into the contested territory. It was not the time, they held, for hasty action, but a moment when they should acquire rights which would ultimately lead to a more advantageous solution of the diplomatic question.

In connection with this treaty, of so much importance to Germany and France, the very recent Anglo-Belgian treaty is of deep interest. Paris papers, we read, declare that the rights of France and Egypt must not be violated, as they will be if the Belgian Congo is given access to the Upper Nile, and England takes the strip of land between Lakes Albert Edward and Tanganyika.

Mr. Cecil Rhodes, it is believed, will not rest until a strip of land, extending along the east coast from the Cape of Good Hope to the mouth of the Nile is under the British flag, and this new accession, gained by the treaty with Belgium, makes the scheme feasible, if the land along the Upper Nile can be secured.

Mr. Rhodes hopes to put a telegraph line along this coast during the present year, and is said to be seriously considering the building of a railway.

WHAT IS A COMET'S TAIL?

By A. C. RANYARD.

No bride was ever covered by such a transparent gauzy veil as that which trails behind a comet as it comes to do obeisance to the sun, or as it backs like a courtier out of the solar presence, keeping its train behind it. It has frequently been noticed that the light of small stars is not sensibly dimmed when the tail of a large comet sweeps between the earth and the star; therefore, to compare the matter of comets' tails with a white mist, or a silver fog in space, is too gross a comparison. A few hundred yards of the thinnest fog or mist we are familiar with cuts down very materially the light of objects seen through it, but the light of a star in passing through the tail of a large comet must have traveled through hundreds of thousands of miles of the nebulous material which is streaming away from the nucleus. The thickness of light-absorbing material traversed by a ray of light makes a greater difference than would at first sight be suspected in the amount of light transmitted through a fog or haze, or other absorbing medium, for the light lost increases in geometrical proportion as the thickness of the light-absorbing medium increases in arithmetical proportion; thus, if a haze ten miles thick reduced the light of an object seen through it by one half, a similar haze twenty miles thick would absorb three-quarters of the light that would otherwise be transmitted, for the second ten miles of haze will halve the light that has been transmitted through the first ten miles. Thirty miles of such haze will reduce the light to an eighth, and two hundred miles of such haze will reduce it to about one millionth, for two to the power of twenty is a little more than a million.

On the clearest summer day the brightness of objects at a distance of ten miles on the horizon is reduced to less than one half by the absorption of the intervening atmosphere—a fact that becomes very evident to photographers who attempt to photograph distant objects, and who find that long exposures are necessary to obtain upon their plates any trace of the blue distance which so charms the eye. The tail of a comet must consequently be far more transparent than the earth's atmosphere; indeed, a mass of gas as bulky as the tail of a large comet would—even if it were a thousand times more transparent than air—act as an opaque screen in space, cutting out the light of the stars, and probably even eclipsing the light of the sun itself, if such a cometary tail should pass between the earth and the solar disk.

The light derived from the tail of a comet is generally found to give a bright line spectrum in the neighborhood of the nucleus, and to be more or less polarized at a greater distance from the nucleus. The bright lines seem to point to the presence of incandescent gas, and have frequently been taken to indicate a high temperature in the region about the nucleus; but the spectrum of the aurora which glows in the cold upper strata of our atmosphere is also characterized by narrow gaseous lines, and many comets begin to glow and throw out tails in regions of the solar system where they can derive but little heat from the warming effect of the sun's rays.

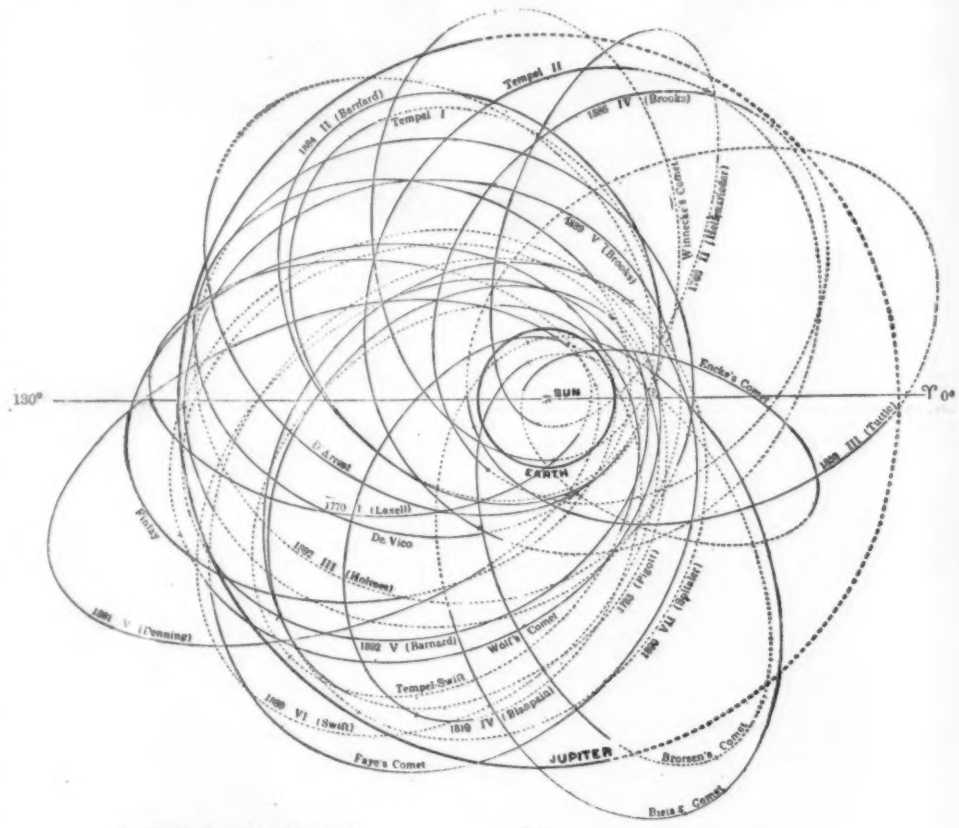
Thus according to Mr. Marth, comet Brooks, at the time of the photograph reproduced in our plate (October 21), was at a distance 1·02 times the earth's mean distance from the sun—that is, it was at a little greater distance from the sun than the earth ever is.* We may therefore compare the temperature of the comet as derived from the sun's rays, at the time that its photograph was taken by Prof Barnard, with the temperature of the moon, and it was shown in the article in the April number that the temperature of the moon's equatorial regions during the lunar day probably does not exceed the temperature of melting ice. Consequently, if the ebullition which was evidently going on in the nucleus of Brooks' comet at the time the photograph was taken was due to the rapid driving into vapor of matter by the sun's heat, the material that was being vaporized must have had a very low melting point, such as is possessed by carbonic acid or substances which freeze at a still lower temperature, such as hydrogen, nitrogen, and other forms of matter which in terrestrial laboratories we are, under ordinary circumstances, only familiar with in their gaseous state.

The way in which comets' tails, as a general rule, slowly develop in size as they approach the sun, and again diminish as they recede from him, would seem to point to the conclusion that the growth of comets' tails is principally due to the intensity of the sun's heat, or to some other cause which varies with the distance of the comet from the sun. But the rapid variations in form and brightness which many comets have exhibited seem to show that the evolution of gas from the nucleus, and the repulsion of matter in the tail, is influenced or in some way partly controlled by some more irregularly varying conditions, such as collisions with meteors, or dust in space, or the passage of the cometary nucleus through a mass of gas. The rapid variations in form and brightness which a comet sometimes undergoes are well illustrated by the four photographs of Swift's comet, taken by Dr. Max Wolf, which are reproduced in our second plate. A still more striking instance of a rapid increase of brightness was afforded by Holmes' comet, which, at more than double the earth's distance from the sun, seems to have suddenly brightened up.

Before attempting to speculate on the causes of these irregular variations in brightness, it may be well to give an account of the phenomena which are usually observable. A comet when it is first seen as it approaches the sun, and also when last seen as it recedes from the sun, generally appears as a small roundish patch of faintly luminous nebulosity, sometimes with a brighter patch or stellar point near the center. As the comet brightens on approaching the sun it generally begins to emit jets or streamers, or to form more or less symmetrical envelopes on the side next the sun, and develops a tail on the side remote from the sun. In the great comet of 1858, usually known as Donati's comet, the action was most symmetrical, one envelope after another rising from the nucleus and expanding, as if the material forming the envelopes was repelled by the nucleus, and was also repelled by the sun, till it was ultimately driven away within a hyperbolic envelope or stratum which formed about the nucleus.

The tail in this and other comets seemed to be composed of hollow cones slightly bent backward in the plane of the orbit. The backward curvature is easily explained, because particles repelled from the comet's head would still retain their original orbital motion, and would fall behind the line drawn from the sun through the comet's nucleus, as they were driven into a larger and larger orbit. The amount of backward curvature of the tail evidently depends on the velocity with which the particles are driven away from the sun, and we find in this and other comets multiple tails, indicating that the different branches of the tail are composed of different materials which are repelled from the sun with different velocities.

But in Dr. Max Wolf's photographs of Swift's comet we find no such hyperbolic strata enveloping the nucleus; the matter seems to be driven directly away from the nucleus, and not in the first instance to be driven into an envelope about the nucleus prior to its being driven away from the sun. Perhaps the discre-



Jupiter's Family of Comets.

The dotted portions represent the parts of the orbits below, *i. e.*, to the south of the ecliptic.

* During our summer in the northern hemisphere the earth attains a distance of 1·01677 times its mean distance from the sun.

pancy may be explained by the repulsion from the nucleus being comparatively feeble, so that the envelopes about the nucleus are small and are hidden by the nebulosity about the head of the comet. In Swift's comet, the streams of matter radiating from the nucleus all seem to be bounded by straight lines, though they radiate in slightly different directions from the nucleus. In the photograph of Brooks' comet there are similar straight rays radiating from the nucleus in addition to the curious curved and branching structure which forms the brightest part of the tail. If we look for an analogy with the more regular structures of Donati's comet, it would seem that the great branching structure corresponds to one of the jets which issued from the head of Donati's comet, while the small straight rays in Brooks' comet correspond to the streams which formed the bulk of the tail in Donati's comet.

The spectral lines observed in the light from the heads of different comets indicate that the chemical constitution of one comet differs from another, and it is perhaps to be expected that the general appearance of comets, and the phenomena they exhibit, should also vary according to the materials of which they are composed.

The light from the remoter parts of the tail is usually more or less completely polarized according to the position of the comet with respect to the sun and earth, in a manner which indicates that the matter of the comet's tail disperses the sun's light as fine dust would do. It seems, therefore, probable that the remoter parts of the tail of a comet consist of very minute particles, whose average diameter is small compared with the wave length of light, and that the material of which it is composed has been precipitated from the gaseous matter driven off from the nucleus.

In 1872 the medal of the Astronomical Society was given to Prof. Schiaparelli, of Milan, for showing that there was an intimate connection between certain meteor streams and comets. He showed that the August meteors revolve in an orbit which is, as near as can be determined, identical with the orbit of comet II., 1862, usually known as Tuttle's comet, and that the November meteors move in an orbit which is practically identical with the orbit of comet I., 1866, known as Tempel's comet. A few years later it was shown that the Andromid meteors are revolving in a track which is practically identical with the orbit of Biela's comet, and that the April meteors are also associated with a cometary orbit. In view of this evidence, it seems highly probable that the nebulous matter which renders comets visible is evaporated from meteor swarms as they approach the sun, and that the matter thus separated from the meteors is repelled by the sun, never to be regathered by the meteor swarm. It would follow that the meteor swarms which are associated with comets are wasting away and losing a portion of their substance every time that they approach the sun. Possibly some of the particles driven away may fall upon the planets and go to augment their atmospheres, taking the place of carbon, oxygen, and other elements which have been absorbed or added to the solid substance of the planet by the processes of life, oxidation, and other chemical changes continually going on; and it would seem to follow that comet-producing meteor swarms cannot last for geologic ages, and that those which are now associated with comets must have been introduced into the solar system within a comparatively recent period—a conclusion which is opposed to Mr. Proctor's and Sir Robert Ball's ejection theory, which assumes that comets and meteors had their origin within the solar system, and were ejected from the sun and the larger planets at an early period when these bodies were in a sun-like state.

The accompanying diagram has been copied from a drawing made by Mr. A. G. Sivaslian, of Northfield, Minn. It represents Jupiter's family of comets, and was originally published in an interesting article by Prof. W. W. Payne in the October number of his *Popular Astronomy*.

It will be noticed that nearly all the farthest points of these orbits (the aphelia) are one side of Jupiter's orbit, and that the places where the dotted portions of the orbits join the continuous ones are in nearly every case close to the orbit of Jupiter. The dotted portions of the orbits are below the ecliptic, while the continuous portions are to the north, so that one of the nodes of the comet's orbit is in every case near to the orbit of Jupiter. If Jupiter were at that part of his orbit at the time when the comet was passing its node, the two bodies would really be near to each other, and Jupiter, by his great mass, would have a very marked influence in changing the orbit of the comet. It seems, therefore, probable that all these comets have at some time been considerably perturbed by Jupiter.

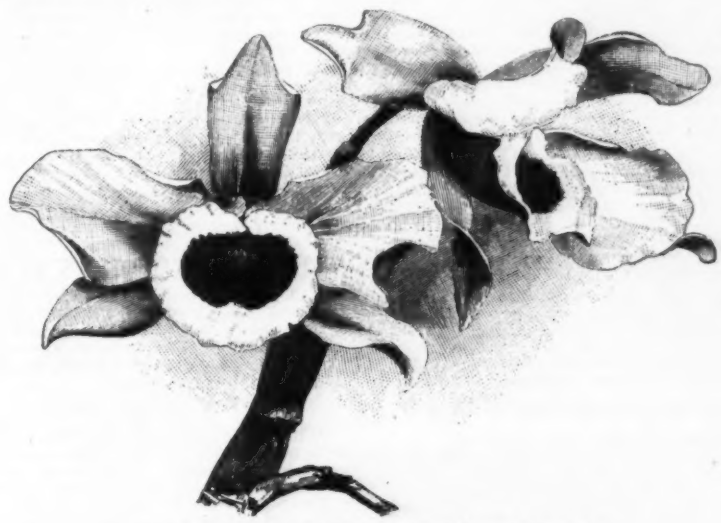
The sun and the whole solar system is moving through space toward a point in the constellation Hercules, having a right ascension of about 269° and a north declination of about 35°. The bottom of the plate corresponds to right ascension 270°, consequently, a vertical line on the page approximately corresponds to the direction in which the solar system is moving—probably at a rate of some ten miles a second.* Jupiter is moving in his orbit with a mean velocity of a little more than eight miles a second, in a direction contrary to the hands of a watch when looked at from above the ecliptic, as in the diagram; consequently, when Jupiter is in the part of his orbit which lies on the left hand side of the diagram he is moving very rapidly through space, with a maximum velocity of about eighteen miles a second, while in the part of his orbit which corresponds to the right hand side of the page he is moving in a direction about the sun nearly contrary to the sun's motion in space, and when going slowest he is only moving through space with a velocity of about two miles a second. The distribution of the aphelia of the cometary orbits shows that Jupiter has caught many more comets when moving rapidly through space than when he is moving slowly. But this is only what might be expected if the comets were all originally caught from outside the solar system, and it forms an interesting additional piece of evidence tending to prove that the sun is actually moving in space, and that the comets of Jupiter's family were not originally members of the solar system.

* This is the velocity determined by Prof. Vogel from his observations of the motion of stars in the line of sight. It seems to be the most trustworthy determination of the velocity of the sun's motion in space that we at present have.

A similar piece of evidence tends to show that the meteors we encounter were not originally members of the solar system. It has long been known that the earth encounters a larger average number of meteors in the autumn half of the year than in the spring half, from midwinter to midsummer; that is, when the earth is moving most rapidly through space it encounters fewest meteors. Exactly the contrary of this would be the case if the majority of meteors were sporadic—that is, if they came from outside space. But with meteor streams captured by the larger planets in the way in which Jupiter has annexed his comet family, we should expect to find the earth most involved among the perihelia of such elliptic streams on the opposite side of its orbit from that on which the larger planets are most successful in capturing such streams. The observed facts can, therefore, be best explained by supposing that the majority of meteors are now moving in closed orbits, which are arranged in a manner that shows that meteors as well as comets were originally captured from outside space. —*Knowledge.*

DENDROBIUM NOBILE VAR. SCHRODERIANUM.

SINCE the Chinese drawing of D. nobile in the library of the Royal Horticultural Society drew attention to this now well known species about three-quarters of a century has elapsed. The first live specimen came home through China and flowered in Messrs. Loddiges' nursery at Hackney, in 1837. Since that time enormous quantities have been imported, and these have been collected over a wide area, while so marked is the habit which prevails in some localities that experienced growers are able to tell whence the plants came from their appearance. Few orchids are better known than D. nobile, and few have shown a greater tendency to vary in form and color. Between D. n. nobilius on the one hand and D. n. albiflorum on the other there is a wonderful diversity of color, and one of the finest of these intermediate variations is D. n. Schroderianum, of which we give a figure. The plant from which the drawing was made is in the celebrated collection at Egham, belonging to Baron Schroder, and so ably managed by Mr. Ballantine. In habit this



DENDROBIUM NOBILE SCHRODERIANUM.

variety resembles a sturdy D. nobile and produces its flowers in twos and threes, from almost every node of the ripened growth. The sepals and petals are large and broad, pure white, with in one or two instances a suspicion of purple at the apex of a segment; the lip is also large, having a deep marone purple disk which approaches black in intensity, this is bordered with creamy yellow which shades to pure white before it reaches the margin. In size of flower this variety has few equals, and is only excelled in this respect by well grown blooms of D. n. nobilius. D. n. Schroderianum is most distinct and beautiful, and readily obtained a first-class certificate when exhibited recently at the Drill Hall, Westminster.—*The Gardeners' Magazine.*

THE SASSAFRAS.

THE sassafras is one of the most interesting trees of the forests of eastern North America. The last survivor of a race which at an earlier period of the earth's history was common to the two hemispheres, it is the only tree in a large and important family of plants which has been able to maintain itself in a region of severe winter cold. The structure of the flowers, like those of other plants of the laurel family, to which the sassafras belongs, is curious and not easily explained with reference to special adaptations to special ends; while the extraordinary virtues which were credited to this tree for nearly two centuries after its discovery have thrown a certain glamor of romance about its history.

Toward the middle of the sixteenth century the French in Florida heard from the Indians wonderful accounts of the curative properties of a tree which they called pavame, and which, for no obvious reason, the Europeans called sassafras. The tree and its virtues were first described by the Spanish physician, Nicholas Monardes, in his "Natural History of the New World," published in Seville in 1569. The reputation of the roots and wood of the sassafras as a sovereign cure for most human maladies soon spread through Europe, and extraordinary efforts were made to obtain them. To collect sassafras was one of the objects of the English expedition which landed on the Elizabeth Islands, at the mouth of Buzzard's Bay, in Massachusetts, in 1602; and eight years later sassafras is mentioned among the articles to be sent home in the instructions of the English government to the officers of the young colony in Virginia.

For nearly two centuries the reputation of sassafras was maintained, and many medical treatises have extolled its virtues, although now it is generally recognized as simply a mild aromatic stimulant. Recently the thick pith of the young branches has been found to yield a mucilage useful to oculists, as it can be combined with alcohol and subacetate of lead without causing their precipitation. The oil of sassafras, obtained from the wood and roots by distillation, is used to perfume soap and other articles, although synthetical oils now replace it for most ordinary purposes; and perhaps, after all, the most useful product of the sassafras tree is the yellow powder prepared from the leaves by the Choctaw Indians of Louisiana, used to give peculiar flavor and consistency to gumbo file, one of the best products of the Creole kitchen. The sassafras is one of the common trees of our eastern forests, and is found from the shores of Massachusetts Bay to central Florida, with a western range which extends to beyond the Mississippi, reaching its greatest size in southern Arkansas and the Indian Territory, where individuals, fully eighty feet tall, with trunks six or seven feet in diameter, are occasionally seen. Usually, however, it attains more modest proportions, and trees exceeding a height of forty or fifty feet are not common; and in the North the sassafras is usually even smaller, and is often shrubby in its manner of growth.

The bark on the trunk of a fully grown tree is often an inch and one-half thick; it is dark red brown and deeply divided into broad ridges, which separate on the surface into thick appressed scales. The branches are short and stout and often somewhat contorted; placed nearly at right angles with the stem, they form a narrow, rather flat-topped picturesque head. The beauty of the sassafras is increased by the lustrous green color of the young branches, which they do not lose until the end of two or three years, when the bark gradually turns rather light red brown and begins to display the shaliow fissures which mark the older branches and young trunks. The winter buds are covered with loosely imbricated scales; of these the three outer enlarge but slightly when the branch begins to grow, and soon fall off; they immediately surround four or five scales which begin to grow with the opening of the bud, and at maturity are obovate, rounded at the apex, concave, coated with silky pubescence, light yellow and much reflexed, forming, when expanded, a sort of involucre. In the axils of these scales the flower clusters appear, and inside and above them are two erect lanceolate scales infolding the leaves and falling when these begin to unfold. The bright color of the involucre, which gradually turns red in fading, makes the sassafras conspicuous and attractive in early spring.

The flowers appear almost immediately after the opening of the bud, and are borne in slender drooping racemes two or three inches long, the males and females usually on separate trees, although perfect flowers may sometimes be found. The perianth or calyx is about an eighth of an inch across when fully opened, pale yellow green, and divided nearly to the base into six obovate, narrow, concave lobes in two ranks, those of the inner rank being a little larger than the others; after the flower opens, the lobes spread and finally become much reflexed. There is no corolla; and in the sterile flower there are nine stamens arranged in three ranks and inserted on the short, slightly thickened calyx tube; the filaments are flattened, elongated, slightly enlarged toward the apex, incurved and light yellow, those of the inner rank being furnished near the base with two conspicuous orange colored stalked glands; the anthers are orange color, fixed on the summit of the filaments, and four-celled, with cells superposed in pairs, facing the center of the flower and opening from below upward by persistent lids. In the pistillate flower the stamens are reduced to minute, flattened, ovate, pointed slightly, two lobed, orange colored, stalked staminodia, or are rarely perfectly developed. The ovary, of which there is no trace in the staminate flower, is one celled, light green and glabrous, with a single ovule and a simple elongated style crowned with an oblique, slightly lobed, stigma. The leaves, which begin to unfold as the flowers open, are involute in the bud, the lowest infolding all those above it. They are ovate or obovate, entire, or often one to three lobed at the apex, the lobes being broadly ovate, acute and divided by deep broad sinuses; at the base they are narrowed into long slender petioles. When the leaves first unfold they are light yellow green, and clothed on the lower surface with delicate, lustrous, white hairs, and at maturity they are dark green on the upper surface, and pale and glabrous or pubescent

on the lower surface, three to four inches long and two to three inches wide, the two forms being produced together on the same branch. The leaves fall in the autumn after assuming delicate shades of yellow, orange, or orange and red. The fruit is a dark blue, thin-fleshed, oblong, aromatic berry, surrounded at the base by the enlarged and thickened, bright scarlet calyx tube, and raised on a stalk which has lengthened during the summer, turned scarlet and grown thick above the middle. The fruit of the sassafras is not produced very abundantly, although in some years it may be found in great quantities; and its aromatic flavor is so attractive to birds that they usually devour it as soon as it begins to color. The wood, which is orange color, with thin, pale sap wood, is very durable when placed in contact with the soil. It is coarse grained, however, and not much used, except in fencing.

The sassafras is a common native tree, and so is usually neglected by those who plant parks and gardens in the United States. No hardy tree, however, is more beautiful at every season of the year or better worth cultivating in the Northern States. Its fragrant leaves and branches, its delicate inflorescence and showy fruit, its immunity from the disfiguring attacks of insects and disease, and the peculiar charm of the autumn colors of its foliage make it a beautiful object; and its relationship to the camphor and other valuable trees of the tropics make it interesting.

The sassafras is easily raised from seed, which should be planted as soon as they are ripe, when they will germinate early in the following spring, or by transplanting the suckers, which it often produces in great abundance. The thick, fleshy roots, covered with thick, fragrant, light yellow bark, which penetrate deep into the soil, make the sassafras a difficult tree to transplant, and only young plants should be selected for this purpose.—*Garden and Forest.*

WINTHROP GARDENS.

A WOMAN FARMER.

A REPRESENTATIVE of the *Ploughman* recently visited a farm where science applied to soil is the rule of action, and where skill and long experience under the directing eye of a real business woman are producing great results.

Winthrop Gardens, conducted by Miss Mary E. Cutler, the well-known and successful woman farmer of Massachusetts, are situated at Holliston, about twenty-five miles from Boston, near Lake Winthrop, a pretty sheet of water from which the gardens were named. The location is quite favorable, being within trading reach of at least 30,000 people, besides having the Boston market and several canneries as a resort for surplus products. The soil of the farm is good, but naturally not better than thousands of other farms in the State. Business methods and modern ideas, rather than natural advantages, explain the success of Miss Cutler's enterprise.

Miss Cutler believes that farming pays. So she says: "It is a good business for one who is young and willing to work. When you hear of a farm running down, you may be sure something is wrong with the owner. I see no reason why a lady cannot conduct a farm as well as anybody. I never do any field work, I merely direct. I do not even board my workmen, any more than I can help, but prefer to hire by the day or year. The business outdoors requires constant attention."

POINTS ON PEACHES.

"What are your specialties, Miss Cutler?"

"At least two thirds of our attention is devoted to the production of vegetables and fruit, which are sold from our teams direct to the consumers, while the surplus goes to the canneries. We have also a large and growing trade in nursery stock, plants, cut flowers, and the like. There are six acres of nursery stock and 9,000 square feet of glass. For live stock we have three horses, eight cows and fifty hens. The milk is sent to Boston, but the eggs are mostly used at home. Among so many branches of the business, some can hardly fail to pay, whatever the season, so that the year's business evens up with a good profit. But our specialties are fruit and vegetables for our market team. One of our most important branches is the peach crop, and it pays."

"Then, according to your experience, peaches can be made a success as far north as Massachusetts?"

"Oh, yes. We have not had a failure of the peach crop for seven years. Two years ago we sold 700 baskets, and last year we sold 450 baskets. We have now 1,400 bearing trees and appearances promise a fair crop for the coming season. The trees are set fifteen feet apart, with standard apple trees in every third row. When the peaches die out, the apples will be in profitable bearing."

"What is your plan of cultivation?"

"We set out trees one year from bud. For this locality, the Early Crawford and the Crosby have proved most satisfactory. We also grow the Late Crawford, Stump the World, Elberta, Mountain Rose and others. The soil of the orchard is plowed in the spring and kept stirred with a cultivator until August. Cultivation should cease by August, or a late growth will be induced, and the trees be winter killed. We fertilized the orchard last season with 1,000 pounds of ground bone and 500 pounds of muriate of potash. In May we trim out the trees and head in the tops four to six inches. This operation prevents the trees from growing out of easy reach and increases fruitfulness. Also about the last of May, or as soon as the fruit buds can be seen, we pinch off the fruit buds except four or five on each branch. The fruit that remains will be much larger, and the trees will escape injury from overbearing.

"Harvesting the peaches is an important matter. One experienced man does it all. The fruit is handled as carefully as eggs. A bruised peach overnight is a rotten peach next day. It is also a nice point to tell the ripeness of the peach, even when hard, by its color. A practiced eye can tell by the deepened red and golden hue that a peach will be mellow next day.

"In marketing this crop, it is the sorting that sells our peaches. We make first and second grades, and our customers know that the quality is always uniform. The fruit is easily sold at good prices. Peach raising has been attracting more notice of late in this region. It seems as if all the farmers are getting crazy to set out peach orchards."

PEARS.

"Among other tree fruits we have an acre and a half of pears; Bartlett, Sheldon, Lawrence and Keiffer. The Keiffer is a success, and sells well in spite of its quincy flavor. It ripens about Christmas time, when the demand is good. There are also several acres of apples, early and late. Our grape vineyard is quite successful. Concord grapes are most productive, but the Delaware is more profitable, selling here for ten cents a pound when the Concord and Worden bring only three cents. Other profitable grapes are the Green Mountain, Pocklington, Diana, Moore's Early and Niagara. The vines are trained on a wooden trellis, with a single rail, about four or five feet from the ground."

SMALL FRUITS.

"Do you raise small fruits?"

"Yes; mostly strawberries, of which we have a field of one acre. For varieties, I would recommend Bubach for early, Belmont for medium, and Parker Earle for late. We set the plants one foot apart in rows four feet distant. In the berry field, as in other parts of the farm, we aim to make the horses do most of the work. Our currant patch is also quite a success. Fay's, Cherry and Versailles prove almost equal in merit. There is no demand for white currants. The plants set at a distance of two feet in rows four feet apart. The cultivator is run between the rows and a pronged potato digger is used to clean out between the plants. For both strawberries and currants the men prefer a potato digger rather than a common hoe. Slug shot is successfully used for the currant worms."

ASPARAGUS—HORSE POWER.

"I see you have a large field of asparagus, Miss Cutler. Do you not find it a hard crop to care for?"

"Not at all. Everything is done by horse power. When the field becomes weedy, we simply cut off the asparagus shoots clean, and run the harrow or cultivator right over the field, plants and all. The weeds are killed and the asparagus is not injured. We keep up the process through the season. Manure is applied in the fall. The rows are four feet apart and the plant only six inches apart in the rows. We prefer the Palmetto variety, which is certainly much larger than Conover's Colossal, and is fully as early. We set our two-year-old plants of asparagus, just the same as any other plants, without any trenching or other extra work. The crowns, however, are sunk a few inches below the surface. We have used a cheap grade of salt to keep down the weeds, and find the plan quite successful. We have never been able to produce enough asparagus to meet the local demand. The soil is kept very rich.

TOMATOES.

"Tomatoes have also proved a success. Most of them are sold from the cart, but the cannery at Franklin will take the surplus at thirty-three cents a bushel. The plants are raised in hotbeds and are set out about May 20. The best kinds are Early Dwarf, Champion, President Cleveland, Boston Market and Paragon. The horse cultivator subdues the weeds and the cut worms are killed with an infusion made from tobacco leaves. We raise enough tobacco for this purpose and to fumigate the greenhouse.

SWEET CORN.

"This year three acres of sweet corn will be grown. It should net $60 an acre at the cannery and furnish some valuable fodder. I intend to build a silo to preserve the fodder. Nearby is a field of two acres, which will be planted to cucumbers. A part of these will be made into pickles on the farm and sold by the barrel at the local markets. There will also be three acres of potatoes, two acres of spring rye, one acre of squashes, and one-half acre of peppers and celery, besides smaller beds of the other vegetables. Our greenhouse and hotbeds, with their 9,000 square feet of glass, require also a great deal of care."

BUSINESS METHODS.

"How do you provide for the labor?"

"Six men are kept busy during the growing season, and two men the year round. The foreman, Mr. Pakin, has been on the place seventeen years. Another man has been employed twelve years, and another four years. Boys are hired to do weeding at from fifty to seventy-five cents a day. It is easy to get berry pickers from the town."

"In marketing you do not rely much on Boston commission men?"

"No; it does not pay me to ship to Boston. The commission men return just what they please. Early peas and apples often sell well in Boston, but for most crops the prices received are not profitable."

MISS CUTLER'S CAREER.

Miss Cutler became sole manager of Winthrop Gardens after her father's death, ten years ago, since which time the business has constantly increased, until it now amounts to a total of three or four thousand dollars annually. The death of her father was very sudden, and no plans had been decided upon for the season's work. Miss Cutler's friends all advised her against attempting to carry on the farm. She might be able to go on for a year or so, they said, but it was absurd to suppose that a woman could make a business success of farming. However, she determined to leave the school where she had been teaching and to attempt what seemed to her the more pleasant and profitable occupation of farming. Proceeding cautiously, only one-half the usual business was planned out for the first season, but each year since the industry has been increased and new ideas introduced. Besides personal supervision of the farm work, Miss Cutler has devoted some attention to music and art and to writing for agricultural papers. She has always been prominent in the local grange, having been lecturer for six years and also secretary. But her chief pride lies in the snug and profitable business that has grown up under her care, and her just claim is that her little estate of sixty-eight acres, nineteen in tillage, is the most productive farm in the town.—*Massachusetts Ploughman.*

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